PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

VOLUME XX

EDITED BY THE PUBLICATION COMMITTEE

PHILADELPHIA
THE ENGINEERS' CLUB OF PHILADELPHIA
1903

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PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XX. JANUARY, 1903. No. 1

1877 TWENTY-FIFTH ANNIVERSARY 1902

OF THE

FOUNDING OF THE ENGINEERS' CLUB OF PHILADELPHIA.

BANQUET AT THE UNION LEAGUE.

DECEMBER 6, 1902.

THE twenty-fifth anniversary of the founding of The Engineers' Club of Philadelphia was celebrated by a banquet held at the Union League, December 6, 1902.

COMMITTEES HAVING CHARGE OF THE CELEBRATION ARRANGEMENTS.

W. L. Austin, 1892.
Chas. E. Billin, 1877.
John Birkinbine, 1884.
James B. Bonner, 1897.
Walter Brinton, 1888.
A. J. Cassatt, 1881.
E. Chamberlain, 1884.
James Christie, 1884.
Chas. S. Churchill, 1885.
Walton Clark, 1897.
F. H. Clement, 1882.
B. H. Coffey, 1888.
Silas G. Comfort, 1892.
Stevenson Constable, 1881.
John H. Converse, 1884.
Wm. A. Cooper, 1878.
Chas. H. Cramp, 1879.
Geo. V. Cresson, 1884.
W. P. Dallett, 1891.
Charles H. Davis, 1900.
Wm. H. Dechant, 1884.
Wm. H. Derbyshire, 1882.
Wm. J. Donaldson, 1892.
Charles Edgerton, 1892.
Wm. C. L. Eglin, 1894.
Theo. N. Ely, 1897.
S. W. Evans, 1898.

COMMITTEES HAVING CHARGE OF THE CELEBRATION ARRANGEMENTS.—*Continued.*

E. Hayward Fairbanks, 1895.
A. Falkenau, 1887.
E. C. Felton, 1898.
Herbert C. Felton, 1885.
Horatio A. Foster, 1901.
Alexander P. Gest, 1879.
E. Graves, 1888.
Wm. J. Gray, 1882.
Frank L. Hand, 1895.
Josiah Harmar, 1894.
W. G. Hartranft, 1892.
A. E. Harvey, Jr., 1886.
Herbert E. Havens, 1893.
D. A. Hegarty, 1895.
Carl Hering, 1882.
Rudolph Hering, 1878.
Henry Howson, 1891.
Conway B. Hunt, 1884.
W. Hunter, 1884.
J. B. Hutchinson, 1884.
Harry W. Jayne, 1901.
Jos. Johnson, 1880.
Philip H. Johnson, 1893.
Washington Jones, 1882.
Jos. B. King, 1885.
Strickland L. Kneass, 1880.
J. W. Ledoux, 1897.
Henry Leffmann, 1892.
Robt. W. Lesley, 1884.
Wilfred Lewis, 1877.
Chas. A. Lindstrom, 1888.
Harvey Linton, 1884.
J. Kay Little, 1883.
Max Livingston, 1885.
Harrison C. Luders, 1881.
Jawood Lukens, 1888.
R. C. Luther, 1886.
Edgar Marburg, 1893.
Saml. R. Marshall, 1884.
D. J. Matlack, 1881.
Wm. H. McCallum, 1884.
Joseph J. McKee, 1884.
A. G. Menocal, 1886.
James S. Merritt, 1888.
Henry G. Morris, 1878.
H. K. Myers, 1896.
William H. Nauman, 1882.
Geo. M. Newhall, 1884.
F. L. Paddock, 1881.
Geo. F. Payne, 1894.
David Pepper, Jr., 1898.
Charles Piez, 1895.
William M. Potts, 1878.
S. M. Prevost, 1885.
Saml. Rea, 1882.
David Reeves, 1880.
Jos. T. Richards, 1893.
W. B. Riegner, 1884.
Percival Roberts, Jr., 1897.
James Rowbottom, 1884.
Oscar Sanne, 1884.
Carl H. Satherberg, 1893.
L. Y. Schermerhorn, 1892.
F. Schumann, 1894.
Louis Schutte, 1885.
E. A. Scott, 1896.
J. Roosevelt Shanley, 1897.
Walter S. Sheafer, 1884.
R. A. Shillingford, 1887.
Charles A. Sims, 1897.
C. S. Sims, 1888.
Edwin F. Smith, 1881.
H. W. Spangler, 1883.
Theodore Spencer, 1897.
D. McN. Stauffer, 1878.
A. A. Stevenson, 1884.
Ellis D. Thompson, 1898.
Heber S. Thompson, 1885.
H. T. Townsend, 1889.
J. W. Townsend, 1878.
John C. Trautwine, Jr., 1884.
Wm. S. Twining, 1896.
Joseph C. Wagner, 1892.
B. F. Warren, 1878.
Geo. S. Webster, 1878.
Wm. Wharton, Jr., 1884.
Wm. H. Wiley, 1884.
W. C. Williamson, 1895.
Otto C. Wolf, 1886.
Paul L. Wolfel, 1892.
Howard Wood, 1885.

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H. G. Riebenack, 1897.
Charles Hewitt, 1896.
Theo. Kolischer, 1888.
Thos. C. McBride, 1892, *Secretary.*
George T. Gwilliam, 1882, *Treasurer.*
Henry J. Hartley, 1884, *Ex-officio.*

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Rear-Admiral Geo. W. Melville, U. S. N.
Mr. Coleman Sellers.

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Charles C. Schneider, Vice-President.

AMERICAN SOCIETY OF ELECTRICAL ENGINEERS.
Chas. F. Scott, President.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Oberlin Smith, Past President.

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Sam'l H. Ashbridge.
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Edward M. Trump.
Ferd. Waechter.
Gen'l Louis Wagner.
Edward Walton.
Richard Wetherill.
Charles G. Wetter.
S. Bowman Wheeler.
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David Thomas Williams.
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David Halstead.
F. L. Hand.
Josiah Harmar.
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Henry J. Hartley.
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D. A. Hegarty.
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H. D. Hess.
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Carl Horix.
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Max Livingston.
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L. F. Rondinella.
C. H. Satherberg.
L. Y. Schermerhorn.
Robert Schmitz.
G. C. Schoff.
F. Schumann.
L. Schutte.
E. A. Scott.
Horace E. Setchell.
J. Roosevelt Shanley.
F. H. Shelton.
Constantine Shuman.
Wm. L. Simpson.
Charles A. Sims.
G. M. Sinclair.
Edwin F. Smith.
Raymond W. Smith.
Henry I. Snell.
Charles B. Souder.
H. W. Spangler.
Philip L. Spalding.
Theodore Spencer.
Chr. J. Steen.
Henry Szlapka.
Heber S. Thompson.
James Thompson.
H. T. Townsend.
J. W. Townsend.
J. C. Trautwine, Jr.
Wm. S. Twining.
A. C. Vauclain.
J. C. Wagner.
W. N. Walmsley.
C. B. Webster.
George S. Webster.
John H. Webster, Jr.
J. P. Webster.
I. Weil.
Robert Wetherill, Jr.
W. Rodman Wharton.
W. C. Williamson.
J. Chester Wilson.
Otto C. Wolf.
Paul L. Wolfel.

MENU.

Small Rockaways.

Celery. Radishes. Olives.

Green Turtle Soup.

Boiled Salmon, Hollandaise.

Potatoes Parisienne. Cucumber Salad.

Roast Tenderloin of Beef, Mushroom Sauce.

French Peas. Potato Croquette.

Menthe Punch.

Quail en Canope.

American Salad.

Ices.

Assorted Cakes.

Fromage de Brie and Camembert Cheese.

Demi Tasse.

Amontillado Sherry.
Haut Sauterne.
Union League. Pommery & Greno "Sec."

After the menu had been enjoyed to the full, each participant was furnished with a unique souvenir, consisting of a blue-print cover and tracing linen pages. The cover was embellished by an elaborate design in which were represented the instruments typical of the various branches of the profession represented in the membership of the Club. The pages contained the Menu, List of Toasts, Committees and Guests of the Club.

The post-prandial exercises were introduced by the President of the Club.

TOASTS.

PRESIDENT HENRY J. HARTLEY: Members of The Engineers' Club of Philadelphia and guests, gentlemen:

We have assembled this evening for the purpose of celebrating the twenty-fifth anniversary of the founding of the Club that bears our name. In order to bring the event to a successful as well as a memorable termination, the committee of arrangements has fittingly selected

as toastmaster a gentleman of well-known ability and unbounded versatility to preside on the occasion,—Mr. James Mapes Dodge,—whom I now have the pleasure of introducing.

Mr. James Mapes Dodge: Gentlemen all: The first toast, "To our President, Mr. Roosevelt."

Mr. L. Y. Schermerhorn: Three cheers for President Roosevelt! (Three cheers.)

Mr. Dodge: Gentlemen: In attempting to pilot you through a part of this programme, I wish to state that my intent is all right. The task of toastmaster to-night, so far as the introductions are concerned, is an exceedingly easy one: but there may be some other things in connection with the duties which I have to perform, in which I may not be quite equal to the task, but in that I am somewhat like the Dutchman who was employed on the Mississippi steamboat to heave the lead. He was picked up hurriedly and he wanted to see how the thing was done. He saw a man out with the lead and give it a heave: "By the mark, one"; he sang out again, "By the mark, two"; again, "By the mark, three." The captain told the Dutchman to go out and do it. The Dutchman gave the lead a heave and called out, "By de mark, von"; at the second heave, "By de mark, von"; at the third heave, he again sang out, "By de mark, von." The captain shouted, "What's the matter with you down there?" "Dat's all right, captain, don't get excited; I know de tune, but I know not de vurds. Dat's all right." (Laughter.) So I hope you will bear with me; I know the tune, but may be deficient in the words.

I will call upon Mr. Schermerhorn, the President of the American Dredging Co., to "Welcome our Guests."

Mr. Schermerhorn: We all believe that the friendships of life and their fruits form the best part of that which makes life worth living, therefore our friends hold a large place in our hearts, and their presence is always prized.

In behalf of The Engineers' Club of Philadelphia, it is a very pleasant duty to cordially welcome you who are at once our friends and guests of the evening, and to express our hearty appreciation of the honor conferred by, and the pleasure derived from, your presence.

A glance over our guests falls only upon those who have so well deserved and often received distinction from their fellow-men, that we cannot hope, through this occasion, to add new honors; but we can and do attest our appreciation of those qualities of heart and mind which have won for you the distinction which the world has given, and

you have made us your debtors in permitting us to feel that, with duties which press so heavily upon every sixty minutes of the hour, you are willing to bank the fires for a little time, and by your presence testify to your interest in and fellowship with our professional guild.

The engineer who justifies his profession must needs be a pretty good fellow, otherwise he could not serve the two great Masters of the Universe, Gravitation and Molecular Force—masters who never discount ignorance, or inexperience, and who never respect Coefficients of Safety—and, more than all, masters who do not hesitate to publish to the world the failures of employees who do not know and respect their laws. Service under such masters cannot fail in developing the highest class of employees.

The engineer must be the most patient man in the world, because he leaves his reputation to be maintained by his works; therefore he plans for and builds for a wider future than other men. He knows that no time limits will serve to condone his errors, and that, in this age of records, his name and his works are inseparable. Our brother engineer, who built the Campanile Tower of St. Mark's, is in these later days criticized by the public, and cursed by officials, because it fell at the infantile age of one thousand years, and one cannot forget that he would be similarly treated if the inherent faults of his poplar piles, grillage platform, and center of pressures had been suppressed for yet another one thousand years.

The engineer stands preëminently as the representative of those forces and their evolution, which have drawn the world into the civilization of the twentieth century; and a glance over our guests falls upon men who, through their life-work, have done more for the true advancement of the world than was done by all the emperors in all the one thousand and six hundred years from Cæsar to Napoleon. We are indeed proud to claim such men as our associates, our friends, and our guests, and we welcome them with all the enthusiasm that can be expressed through words and deeds.

A word in relation to the event which we celebrate this evening. During the Centennial Exposition held in this city in 1876, the American Society of Civil Engineers and the American Institute of Mining Engineers established headquarters in Philadelphia for the convenience of American and foreign engineers visiting the Exposition, and throughout its continuance an open house was kept at these headquarters, and weekly meetings were held on Thursday evenings.

The remembrance of the pleasure and success of these meetings led

a few of our local engineers to organize The Engineers' Club of Philadelphia, on December 17, 1877, with a charter membership of twenty-three, of which Messrs. Chas. E. Billin, Wilfred Lewis, M. R. Mucklé, Jr., and Wm. G. Neilson are among its present members.

It is recorded in the minutes of the first meeting that a member offered the startling suggestion, with a view of permitting existing engineers to maintain control of engineering positions, that a system be elaborated and inaugurated for suppressing young men who might contemplate entering the engineering profession. The suggestion was throttled on the spot, but possibly a great mischief had already been done, since, as Professor Marburg, our Club historian, has suggested, "the transition from this idea to that of the modern trust is so easy and obvious, that the responsibility for the latter rests plainly upon our shoulders."

Under the original plan the membership was to consist of civil, geological, mining, and mechanical engineers and architects, and such others as were interested in or allied with these professions. The now familiar electrical engineer was then so little known that he received no specific enumeration among those eligible for membership; the electrical engineers, as a body of highly trained specialists, now form an important part of our membership.

While modesty is the ruling characteristic of the engineer, nevertheless our Club forebears were sustained by an unfaltering trust in the ultimate destiny of the Club. This is shown in one of the early resolutions by which the library of the Club was made a circulating one at a time when it consisted of only a single volume. The Club has now a fair reference library, the nucleus of which was the generous gift of Mrs. Joseph Harrison, in 1879.

While the Club has been conservative at all times, it has been prominently identified with important national, State, and municipal legislation upon subjects with which the engineer was in sympathy. Among these was the geodetic survey of Pennsylvania, the need for which was emphasized by the fact that when the line was retraced between Pennsylvania and Delaware, it was found that a member of the Legislature of Pennsylvania lived in the State of Delaware.

The Club on numerous occasions has extended its courtesies to technical and scientific societies, and to distinguished foreign visitors, notable among which was the reception in honor of Count Ferdinand de Lesseps, in 1880, and that tended the delegates of the Engineering Society of France to the World's Fair, in 1893.

Since the date of our organization, twenty-five years ago, the Club has steadily developed, and it now enters upon the second quarter century of its existence with a membership of nearly five hundred, and with a list of honorary members of world-wide reputation. Its frequent and well-attended meetings bring its members closely together, while a spirit of loyalty to their chosen professions and to each other animates and controls all. As a prosperous, united, and happy family "with modest pride may we look upon its past, and ask no better earnest for its future."

Mr. Dodge: It is with regret that I am obliged to announce that Brigadier-General Wm. P. Craighill, Chief of the United States Engineers, U. S. A., retired, got as far as Baltimore, on his way to the banquet, and was then obliged to retrace his steps on account of official duties. We received a message from Mr. Craighill in which he says:

"Reaching Baltimore on way to Philadelphia, I find myself obliged to go elsewhere at once, and am prevented, to my great regret, from attending banquet. Please present my hearty congratulations to the Club and very best wishes. May it live long and prosper."

In his absence Mr. Oberlin Smith, the President of the Ferracute Machine Co., has kindly consented to say a few words, expressing our regret at the absence of General Craighill, and for the engineers of the United States Army. I have the pleasure of introducing Mr. Oberlin Smith.

Mr. Oberlin Smith: Mr. Toastmaster, members of the Union League; members of The Engineers' Club of Philadelphia—my fellow-engineers in general and *gentlemen*. (Laughter.) That's not new, though.

I am reminded of a story of the late Wm. E. Dodge, of New York, when, upon one occasion as toastmaster, he called upon some gentleman, who was totally unprepared to say anything, to make a speech. The man got up and said: "I would like to know whether this is a New York dodge or a Philadelphia dodge." (Laughter.) Now I have not any doubt as to the kind of dodge that has gotten me into this scrape, because I cannot say anything without thinking it over a day or two beforehand and looking up some witty sayings. I know that every other man whose name is down on this lovely programme (tracing muslin, etc.) has been preparing speeches, and I am informed that the typewriter girls have set their machines at wide lines in order to allow for much revision. I have had no opportunity of that kind, and I know that all the set speeches will be so thoroughly studied and so

dignified that I really feel that what I have to say will appear very frivolous in comparison. Mr. Dodge should not have called upon me. He should have said what is to be said himself. He is always dodging things. I won't say he dodges the police. He early resolved, "I will never get into the hands of any old policeman, because I will be good." He has been good ever since; that is the reason he escaped. I will tell you confidentially that he said to me just now that I am to say something in the place of my friend General Craighill, which, of course, I cannot do properly; and he intimated it must be very short and dignified, befitting the army of the United States, and rather slow. If this had been a New York dodge, he would not have said it; but that reminds me of the New York fellow that came to Philadelphia and heard a good deal about things not being quite as swift as in New York, and he was shown around the town. He wanted to see that beautiful Public Building which only took twenty or thirty years to build. He thought they must be pretty swift to get that up 555 feet and $\frac{5}{8}$ inches, so as to beat the Washington monument. Just then he noticed a man standing on the statue and thought that Philadelphia must be a pretty dangerous place. Suddenly the man lost his hold. The Gothamite watched the man fall down to the granite pavement and then get up and run after his hat. When asked, "Why, man! Aren't you smashed?" he replied: "Well, mate, in Philadelphia, you know, we fall *slowly*." That is the only way I can account for my friend on my left intimating that I am to do things in this way; but, gentlemen, I really feel it a great honor to represent, in the slightest degree, my friend General Craighill, Army Engineer, whom many of you know. I am very sorry he is not here to-night, and don't know what he would say, unless to ask what I know about military matters.

The army engineer was the original engineer. When society did not have all the ramifications it has at present—the luxuries then unknown to kings—the wonderful facilities for traveling—when men chiefly wanted to kill each other, the army engineers stood faithful as the only engineers. They built the forts and the catapults to smash them with; and, later, they made the great roads and bridges of Rome which have lasted even until now—work fit for the civil engineers of modern times.

As mechanical engineers these military men build great guns to withstand 50,000 pounds per square inch. They deal with these enormous strengths in metals and deal with all the fine points—and they

set an example to the rest of us. As mining engineers they dig mines and then blow up the fellows that disagree with them. As electrical engineers they measure the velocities of great projectiles and train guns by electrical appliances. As administrators and practical business men they manage great public works with ability, with honesty, and with success. In fact, the army engineers are the representatives of engineers of every kind and the originators of the whole profession.

Another point about army engineers that attracts my attention is, we might not now be here, and there might not have been any engineers at all, if it had not been for the great safety to human life resulting from the dynamite, and explosive shells, and machine guns, and all the horribly destructive engines that, the economists tell us, will scare men into making war no more. Hence the less war in the world and its consequently increased safety. Thus, again, if it were not for the army engineers we would all have been dead and there would have been no engineers at all. (Applause.)

MR. DODGE: May the warmth of our welcome atone in a measure for the recollections of hardships experienced by our eminent Navy Engineer, Rear-Admiral Geo. W. Melville. (Three cheers for the Admiral.)

REAR-ADMIRAL GEORGE W. MELVILLE: Mr. Chairman and gentlemen: I have been called on to speak this evening on behalf of the naval engineer. Unlike my good friend, Oberlin Smith, I *did* have a typewriter go to work for fear I might make a mistake; therefore, *brother*-engineers (I am delighted always to be with my brothers), I am proud and pleased to take part in this celebration—to be one of this happy gathering, and help to sing the praises of our great and glorious profession.

Before speaking of "Our Navy Engineers," permit me to touch upon that general thought which dominates us to-night—"the engineer." What, we may ask, is the full significance of this thought or term?

The term "engineer" is the most comprehensive one in the active work of man. His efforts are only limited by the possibilities of physics and their mechanical application, and by the necessities of commerce, which latter always govern his opportunity for execution. He advances, step by step, and hand in hand, with the advance of science and invention, aided by capital and labor, and along strictly business lines. His sphere of action and influence is world-wide.

In peace and war, he is, of necessity, preëminent, both ashore and

afloat; he, the organizer and director of force, the master of materials, and the conserver of energy, for efficient and economic use in industrial projects, or to meet the demands of national defense. His advice is necessary for the shaping of a wise government policy in both civil and military matters.

He is thus the *pilot* and pioneer, on *sea* and land, of the material welfare of his race, and the preserver and defender of a nation in times of stress and danger. He is, in the truest practical sense, the "trusted leader"—man's "guide, philosopher, and friend."

As the tree is known by its fruit, the engineer is known by his work. There is no professional man whose title to the "immortality of worth" is so readily demonstrable as the engineer's. He, more than any other, can point to the enduring results of his worthy labor and say, "That is *my* work," and rejoice in the manifest proof thereof.

"Our Navy Engineers," we can say with truth, have good reason to rejoice at the success of the work which the nation has entrusted to them. Such success proves that they have been strong in courage, sound in thought, and efficient in deed.

They have stood the shock of recent battle, and won new victories for our country. In such a signal instance as the splendid performance of the "Oregon," not to mention other achievements, they have realized the fondest dreams of patriotic hearts.

In this age of engineering triumph, justice demands the recognition of the engineer; and our naval engineers to-day have their rightful place and standing in the fleet. In this respect, the United States, as it has done so often, has blazed the way—for at this very hour all the principal countries of Europe are earnestly considering the status of their naval engineers.

The efficiency, sense of personal responsibility, and devotion to duty, of our naval engineers, cannot be too great, for theirs is a sacred privilege, that of safeguarding the nation, and maintaining its honor, on the seas. They must keep the engineering faith!

Grave problems confront the navy to-day, in consequence of the position of the United States as a world power; and upon the strength and efficiency of its armed force afloat the nation will greatly depend in the days to come. "Our Navy Engineers," not found wanting in the past, are doing their duty in the present, keenly alive to the possible requirements of the future. Our new navy has been hammered out by the combined efforts of the whole engineering world of the United States. Our naval engineers would be the last ones

to take to themselves the sum total of credit for the success of our ships. They will always expect and appreciate that co-operation and sympathy of their brother-engineers in civil life which have contributed so much to the success of their previous efforts; and, gentlemen, it is only in this way, by the concentrated energies and united labors of the entire engineering profession, in every important project, that we can carry forward the greatness and grandness of the nation.

Mr. Dodge: Gentlemen, drink with me the health of Rear-Admiral George W. Melville, United States Navy. ("He's a jolly good fellow" was then sung by the auditors.)

Mr. Dodge: Gentlemen, the next regular toast—that of "Our Honorary Members"—will be responded to by Mr. James Christie. Mr. Christie will also read a few letters that we have received from some of those whom we have invited that were unable to be with us this evening, and also take pleasure in introducing our old friend, Mr. John Fritz. (Applause.)

Mr. James Christie: Gentlemen, our guests, and fellow-members of The Engineers' Club: The rules of our Club require that an honorary member must be a person who is broadly acknowledged as "eminent in his profession." It therefore follows that the gentlemen that grace our list of honorary members must be necessarily men of advanced years and must be recognized by the Club and the community as being prominent in the profession and as being entitled to our respect and our confidence. They are limited to ten in number. At present we have only seven. I will read their names: William P. Craighill, John Fritz, Charles H. Haswell, Herman Haupt, B. F. Isherwood, George W. Melville, and Coleman Sellers. (Applause.) Only very recently our eighth member, Mr. William Hasell Wilson, passed over the great divide in the full ripeness of years and experience, leaving behind happy memories of his personal worth and his professional abilities. We have the pleasure of having with us this evening three of these gentlemen. We expected a fourth, but General Craighill was unfortunately detained. We have interesting letters, which I will read, from the other three.

It behooves us all, especially our younger men, to reflect on the careers of those who have been pioneers in the arts that were in their infancy when these men were young. The giant industries of to-day developed from the toil and struggles of those who, with primitive tools and few precedents to guide them, hewed their way through the trackless forests, where now ample harvests reward the efforts of those who

reap where the others sowed. The development of the modern machine tool, that miracle of mechanism which enables us to reproduce with accuracy and celerity all other machinery, is closely identified with the name of Dr. Coleman Sellers.

When we contemplate the magnificent fighting machines that sail the seas, actuated with the most complex and intricate mechanism, we can realize the burden that has been so lightly borne in later years by George W. Melville.

When we visit our large iron and steel works, the modern blast furnace and rolling mill, and reflect on what their prototypes were half a century ago, those who have listened to him know what an interesting story can be told by our good friend, John Fritz.

The absent ones will address you through their letters, which we will now read: I can express for the Club our pride and gratification at having even these few of our venerable friends at our board this evening:

From Herman Haupt:

"WASHINGTON, *November 13th.*

"Your esteemed favor of the 7th instant, inviting me to attend a banquet at the Union League, as a guest, on December 6th, was forwarded and received in transit before my return to Washington. I do most keenly appreciate your kindness and the honor conferred by the invitation as a guest of the Club, and the temptation was almost irresistibly strong to break my rule for some years, to decline all invitations to social functions. I am now nearly 86 years of age, and the acceptance of your invitation might be attended with some risk to health, which has been well preserved by care in regard to hygienic conditions. I was expected to attend the Centennial at West Point last June, and occupy the chair as the oldest living graduate, and declined the urgent requests of the Superintendent and other prominent officials.

"I am aware of the fact that I am the senior honorary member. The first were Moncure Robinson and myself. After his death I remained the only one for a number of years. Hasell Wilson left us during the present year. We were associated in engineering work more than fifty years ago, and he was one of the few invited guests present at my wedding in 1838.

"I appreciate the work of The Engineers' Club, and regard its proceedings as a very creditable publication. If I find myself in Philadelphia at the time of one of your meetings, I will endeavor to attend;

but I am becoming quite a back number; all my old associates have departed. I am the only survivor of the original engineer corps of the Penna. R. R., of the Transportation Department, of the Edgar Thompson Board of Directors, and of those who held prominent official positions during the Civil War, and I am now awaiting the call of Charon to be ferried across the Styx.

"Yours very respectfully,

"HERMAN HAUPT."

We almost hoped against hope to have our venerable member Mr. Haswell with us. He is nearing the century of his years, and enjoys the unique distinction of being not only the oldest, but the first steam engineer in the United States Navy,—and has not yet discarded the harness of his profession. He sends his greetings in these words, from New York, dated November 10th:

"I have the honor of receiving your courteous invitation to attend the Twenty-fifth Anniversary of The Engineers' Club of Philadelphia, and I much regret to forego the great pleasure it would give me to accept it; but the weakness of my heart precludes the fatigue of the travel and the excitement of meeting my associates under such a flattering condition as your invitation presents.

"I would gladly, if at all practicable to do so, avail of the opportunity to verbally express my sense of the advantages derived by our profession by the signal labors of Philadelphians; in the reports of the 'Journal of the Franklin Institute,' the published proceedings of your Club, and the book of the Trautwine, Sr., and also more fully to refer to the early conditions of our profession. Thus, masons and carpenters, unaided by architects, designed and directed the construction of buildings, which were then not of a weight to require even pile driving for a foundation, and when pile driving was resorted to, in the building of piers and bulkheads on water-fronts, the ram was hoisted by manual labor applied to a crank. Concrete, Beton, and aught other than cobblestone street paving were practically unknown.

"Again thanking you, and expressing my sincere regret, I am,

"Very respectfully,

"CHAS. H. HASWELL."

Again, from New York, November 13th:

"In reply to your highly appreciated invitation to the Anniversary Banquet of The Engineers' Club of Philadelphia, at the Union League,

on the 6th of December next, I regret to state that my physical condition does not permit me to attend. My physician has, for some time past, vetoed my acceptance of any such invitations, even in this city, much less one involving a winter journey. And among the sacrifices imposed by my advanced age, I must now include that of not meeting my professional friends and peers on the occasion to which you have so kindly invited me.

"Very truly yours,
"B. F. Isherwood."

I will avail myself of the suggestion of Mr. Dodge, and ask my good friend, Mr. John Fritz, to say a few words. He always says he is not a speaker and does not want to speak, but if you could only sit down with him privately you would know he is mistaken. He is one of the best speakers we have, and I know he will be pleased to say just a few words to you. (Applause.)

Mr. John Fritz: Fellow-engineers and gentlemen: I have been completely taken in and done for. It was the understanding that I was not to be called on to say a word. Mr. Dodge, our Chairman, said he was going to preside and I did not believe him. I was invited here by Mr. Hartley, who wrote me a very kind, affectionate letter, and I accepted the invitation. I had some little doubt about the probability of my getting here, and Mr. Christie persuaded me to come with the understanding I was not to say a word. Now, I could sit down in a corner and tell you, gentlemen, a great deal, but I am not a public speaker, never have been, and, besides that, I don't want to be.

The first thought that occurred when I came here to-night, was that some one came a "Dodge" over me. Now, that is not all. I thought I had something to do with the invention of the three-high mill. This gentleman, Mr. Dodge, said before a Boston audience, within a year (and you know they are the most intelligent people on the face of the earth—at least they think so), that me and Fritz invented the three-high mill. He said me and Bob Hunt introduced Bessemer. Now, I was a little like the man arrested for horse stealing. After his counsel was heard and it was all over, he was asked, "Did you steal the horse?" He said, "I thought I did, but now I doubt whether I did or not." (Laughter.) But that is not all. A gentleman sitting alongside me, when Mr. Dodge made this remark about inventing the three-high mill, asked me if that was so. I said I didn't know. About five or six thousand men claimed to have something to do with it, and he might

be one of them. Well, I said, I thought he was a pretty old man, but didn't think he was old enough for that. Now, gentlemen, I would like to talk with you very much, but I cannot say much on that subject. I'm a modest man, but if I could get half a dozen of you in some corner,—as I said before, I am not a public speaker, have never tried it, and I don't want to begin at these late days of my life,—I might tell you something.

I thank you all for your kindness in having me here to-night, and it is always a pleasure to meet engineers, especially the younger ones, and I see many here to-night who have got to take the places of the older men. Of all the professions, the engineer's is the noblest and the grandest. He is one that has great responsibilities on him. There is no class of men, as our friend Mr. Schermerhorn, and also Mr. Smith, said, that deserves the credit and has done more to produce the results and make the country what it is, than they have. It was they that built the great railroads of the West which have transformed the wilderness into cultivated farms and homes for millions of happy and contented and intelligent people; it is they that have changed the husbandry, the old simple farm methods of our forefathers, into a highly organized industry. Go where you will, sail where you will, you will see the work of the engineer. He has brought civilization to all parts of the world. He is found in almost every branch of business. There is scarcely anything that the engineer has not had something to do with, and we have a responsibility upon us all, and the responsibility is great in the work of this country which is before you. People say at times, "What are we going to do hereafter?" When I was a boy, sixty-four years ago, in October last, I left the work of the farm and went to learn country smithing. If any one had told me it would be possible to see what was going to take place within these sixty years, I should not have believed them. It would not have seemed possible to produce such marvelous results. The results to come are still equally marvelous and will continue. You gentlemen here to-night, you younger men, will be the people that will take part in the future.

Now, I thank you, gentlemen; I did not know what I was going to say when I got upon my feet. Now I have said the few words, and I can assure you I have had a very pleasant evening and it has been a great source of satisfaction to me to be here. (Applause.) (Three cheers for Uncle John.) Gentlemen, I thank you again for this hearty welcome. It will be an evening that I shall long remember, I assure you.

Mr. Dodge: Gentlemen, we have with us one who might have been a playmate of Mr. Fritz in the early days in his neighbor's fields of scientific research and engineering work, and I know you will join me cheerfully and heartily in paying homage to our honorable member, Mr. Coleman Sellers. (Three cheers.)

Mr. Coleman Sellers: Mr. Toastmaster, I think, is coming a "dodge" on me. I came here not expecting to say a word. I promised myself that I would not say anything. I have listened with much pleasure to the many interesting remarks made this evening, but I have derived the greatest pleasure in considering what this Club has become since the time (I do not know how many years ago) when a meeting was held in my own house—one of the preliminary meetings that led to the formation of the Club. I have always had the warmest feeling towards The Engineers' Club, and have watched with close interest its progress; but I have not taken a more active part in it because I am getting to be a rather old man and have a great deal of work still to do before I retire. I believe that all engineers can only live by working. To me, work has been my life. An industrious mental and physical employment is the pleasure of life, and when I think of all that has been accomplished within the limit of my own life and note the progress that has been made in engineering from the time it was simply cut and try to the time when the highest technical education has become necessary to make an engineer successful, it seems amazing, the rapidity of the progress that has taken place. Speaking of what had been accomplished at the time of the Centennial, the exhibit there of electrical machinery was simple, and one of these tables would hold all that was then to be exhibited in the way of dynamos or motors, or anything of that kind. I was present in the large hall when the first intelligible word was transmitted over a telephone, not expecting it would be understood. Sounds had been transmitted, but intelligible words had not been transmitted until one Sunday when experiments were made, in the presence of the Emperor of Brazil. But the most interesting thing to me is the marvelous advances that have been made in electrical engineering.

When the attempt was made to "harness Niagara," it was thought at first it would be a water-power company, to furnish water to those who wanted to erect manufacturing establishments, and to furnish means to convey the water away from their turbines. It was doubted if the time was ripe for the development of power and its transmission, and I am now glad to say that I have lived to see

this later conception realized. When the Cataract Construction Company first considered the development at Niagara and were undecided as to how it should be carried out, there were no customers for the power that has since been so rapidly taken up; but before the first wheels were started the people who wanted power in this form were being abandoned, so that in the very beginning the whole idea of a water company had to be given up and a power company substituted for it. I mention this only as an example of the wonderful advance that has been made since 1890.

In 1890 the largest turbine that had ever been built was not over one thousand horse-power. To build a turbine of five thousand horse-power seemed to be almost too big to be dreamed of. When all the principal engineers of the world were asked to submit plans for, first, the development of power, and, second, its transmission, a large sum of money was expended for the information that was desired by the Cataract Construction Company; but of all the plans submitted, none were feasible; and yet, with full certainty as to what could be done, the work went on, and even in 1893 it was still undecided how the development should be made. At that time such an authority as Sir William Thompson was entirely opposed to using the alternating current. He believed that there was no demand for the alternating current; that the direct current only would be worth introducing. In spite of that, the alternating current was adopted, and the two-phase current was adopted, and it has been a success from the beginning. One customer takes fifteen thousand horse-power, for the single item of carbide of calcium, and that company cannot get the amount of power it wants. So also for the making of aluminium; and the amount of power that is wanted for the other electro-chemical operations fairly staggers one to think of the progress that has been made in this short time; and all this has been done by the engineers of the country. All has been accomplished by furnishing power in the form of energy that would enable manufacturers to perfect the various electro-chemical operations that are now being so successfully carried out.

When I was a mere boy, about nineteen years of age, coming from a farm, I went to Cincinnati and took the position of draftsman in the Globe Rolling Mill, and my first experience with a rolling mill was a three-high set of rolls, spoken of this evening. I suppose that was in 1846, after Mr. Fritz had invented them. Am I right, Mr. Fritz? The wire-mills we had in use at that time used a three-high mill for making wire rods, but that was, of course, a small affair—probably not so big as the three-high mills used for rolling rails and the like.

I feel the greatest interest in the rapidity of the growth of the colleges that have enabled engineering to be taught, to apply the higher mathematics, with a full knowledge of physics and chemistry and the higher branches of engineering. When I was first attempting to work as an engineer I had to be, as every one has to be, a student, and a hard student, and I have had to carry on the effort of self-education from that time to the present. There is one thing I have not learned in the whole of that period, and that is, how to make an after-dinner speech; and so I can only thank you for the kind attention to the few words I have said, being totally unprepared, and thank you all for the invitation extended to me to be present at this time, and which I have so fully enjoyed. (Applause.)

MR. DODGE: Let us drink the health of Mr. Coleman Sellers. (Three cheers.)

MR. DODGE: Gentlemen: The response to the toast "The Engineer of the Twentieth Century" will be made by Mr. Scott, President of the American Institute of Electrical Engineers and of the Engineers' Society of Western Pennsylvania. I take great pleasure in introducing Mr. Scott.

MR. CHARLES F. SCOTT: Gentlemen: It is significant that the response to this toast is assigned to the representative of the Engineers' Society of Western Pennsylvania. This society represents the engineers of Pittsburg, the city above all others preëminent in its industrial and engineering works in the country which is assuming the industrial supremacy of the world. The products of Pittsburg owe their inception to the inventions and designs of the engineer; under his supervision they are manufactured; and in turn they become the materials which other engineers employ in the construction of buildings and railroads and power plants throughout the whole world. This is the age of steel; Pittsburg furnishes the steel. This is the age of electricity; she produces the largest dynamos. The tonnage of the Pittsburg harbor, notwithstanding shallow bottoms and low bridges, exceeds that of the New York harbor. Industrial Pittsburg!—of the engineer, by the engineer, for the engineer!—typical of the present, significant of the future! Do you ask me to portray that future? I ask you to look back fifty years to the time when the first railroad bridge across the Allegheny, built against the protest of hack drivers and sympathetic citizens, brought together the track from Ohio and the track to Philadelphia; it brought them together, but it did not join them; for the State Legislatures had ordained that the gauges of

the tracks should be different, in order to prevent domestic cars from wandering too far from home. Compare conditions then with those now. Note what the engineer has done since some of those present reached middle life. Who will venture to predict what we young men may see before we become old? It is with pride that I see how my own city—Smoky City of the Keystone State, the city of engineers and of industry—is growing in influence. A week ago a Philadelphia paper quoted a multi-millionaire thus: "Pittsburg, instead of Wall Street, must be considered hereafter as the potent factor in the continuation of our national prosperity." When money rates go up in Wall Street and wage rates go up in Pittsburg simultaneously, it is the industrial thermometer which most truly indicates the real prosperity. *Enter* engineer; *exit* speculator.

It is significant, also, that the response to this toast is assigned to the representative of the American Institute of Electrical Engineers. This organization represents the electrical engineers of America—the country above all others preëminent in electrical activity—at a time when its applications are making this the Age of Electricity. For a retrospect of general engineering we appealed to the memory of men past middle life; but the electrical awakening is within the easy memory of us all.

Electrical work is seldom independent. It does not stand alone, complete in itself. Electricity is usually an instrument, a means to an end. It is not energy derived at first hand from electricity which enables the car to move and the crane to lift a weight. It is power derived from the engine which happily can be transmitted by electric wires better than by shafts, or ropes, or belts. It is because electricity is primarily an agent, a means, that its applications have been so diversified, so extensive, and so far-reaching in their effects. The telegraph, the cable, the telephone have had a profound effect upon political, commercial, and social affairs. The applications of electricity bring evolution of new methods as well as the revolution of old ones. It is a new instrument which has given to the whole world a new method of doing things.

The electrical engineer follows the new gospel, the Gospel of Service. His mission is helpfulness. Through his aid the mining engineer lights his mine, drives his fans, pumps, and drills, and conveys his product. Through his aid the mechanical engineer has modernized the machine shop by the electric crane and by motor-driven tools which increase output and reduce cost. Through his aid the railway engi-

neer has replaced the horse-car by the people's automobile which for a few cents will carry anybody from city to suburb more quickly than it was possible by any means at the command of even the millionaire a dozen years ago, and that, too, with the added comforts of warmth and light. Through his aid a new realm is opened to the chemist in the field of electro-chemistry. Through his aid the engineer of plant life, the farmer of the West, transforms the desert into a garden by motor-driven pumps and the distant water-power. Through his aid the engineer of human life is given a new sight to penetrate the living body and a new stimulus to excite the inactive muscle. Through his aid the luxuries of yesterday have become the necessities of to-day, and the impossible has become the commonplace.

The great discovery of the nineteenth century was CO-OPERATION, the effectiveness of concentration, the efficiency of largeness. Compare the old days of the hand-loom in the home, of the shoemaker at his bench, of the individual oil well and coal mine, of the small railroad, and of the small factory; compare these with modern methods, pregnant as they are with unbounded possibilities—possibilities of good and possibilities of evil; of good, because the engineer has provided the means for doing the world's work far more efficiently; of evil, because the social, the industrial, the commercial systems have not kept pace with the advance made by the engineer, but are still tainted with injustice and selfishness.

The tendencies of the nineteenth century projected into the future reveal, in dim outlines at least, the engineer of the twentieth century. He is to deal with large affairs in a large way. He is to be closely related to every department of modern life. He is to become a chief factor in adjusting and operating the intricate mechanism of a new civilization. He is to advance to administrative positions for which his knowledge and his training peculiarly fit him. Note a few present examples. At the head of the Pennsylvania Railroad, directing its vast affairs in the present and planning to meet the demands of the future, is an engineer surrounded by engineers—President Cassatt. (Cheers.) At the head of the interests with which I am connected is a man, successful as organizer and manager and financier, a genius in his foresight, but first of all an engineer, George Westinghouse. (Cheers.) Sound judgment, breadth of view, integrity of character, the ability to understand and to control men as well as matter, to direct human forces as well as physical forces, are essential to the engineer of the future. A recent event which has aided in bring-

ing America to preëminence is the victory of our Navy. A naval battle is a contest between fighting machines, and these are the products of the engineer. All honor, then, to the engineer, so fittingly represented here to-night by Admiral Melville. (Cheers.)

Besides their new relations to others, there will be new relations of engineers among themselves. All that I have said so far emphasizes what we all know—namely, that the several branches of engineering are intimately interdependent and correlated. Take a single instance of large work—the extension of the Pennsylvania Railroad into New York city—the tunnels under the Hudson and East Rivers, the terminal facilities and the electrical equipment—and endeavor to name an important branch of engineering which is not essential to this undertaking.

The work of the future demands co-operation, not clannishness; unity, not jealousy. Engineers must be specialists; therefore they must work together. The several branches of the profession have their individual interests; they have a larger common interest. As we marvel at what the engineer has done, as we attempt to picture what he may accomplish, do we realize the far-reaching responsibilities which confront us? Shall we rise to meet them? We gave to the world the steam engine, the steam vessel, the railroad, the telegraph and the cable, machinery, industrial processes, the electrical central station, the fundamental requisites which underlie co-operation. Is it not time that we apply to ourselves the great lesson of the last century? What organization stands before the world as representative of the engineering profession? In what way do engineers present themselves to other professions? A noted lawyer recently addressed the annual banquet of a local engineers' society containing members of national and international reputation. His remarks were based upon the idea that all engineers were co-ordinate with a common chainman, and they would have been positively insulting but for his air of blissful ignorance. A few years ago a gentleman of eminence, in addressing the American Society of Mechanical Engineers, advised its members not to join in a machinists' strike. Has the engineer been accorded the recognition and the reward which are his due? In what way do engineers co-operate to advance their own profession by mutual helpfulness and by undertaking measures which advance the efficiency and the usefulness of engineering work? There are national engineering organizations of various kinds, the civil engineers, the mining engineers, the mechanical engineers, the electrical engineers, the ar-

chitects, the naval architects and marine engineers, the engineers in the army and the navy, and there are the chemists, the electro-chemists, and others. In general each knows that other societies exist, and they are mutually respectful; but there is some suspicion here and there that the others are a little too exclusive or a little too common, or that they are a bit jealous. These are the murmurings of littleness, not of largeness.

The several engineering professions, like the constituent States, have their representative bodies, their legislatures; but why should there not be an Engineering Congress as well? Why not a national representative body to stand for the profession of engineering as a whole, to promote a harmonious co-operation which will strengthen each and elevate all?

An incident of the past year is an auspicious omen. Four great societies have co-operated; they have taken a step which will bring recognition to the deserving individual and credit to the engineering profession. They have founded a medal, and at a recent magnificent dinner they have announced the award of the first John Fritz Medal to the venerable man who has just spoken, John Fritz himself. But not less significant than even the medal is the discovery that the societies can work together, and that by doing so they can accomplish worthy ends. (Applause.)

In the vision of the future, may we not discern a reflection of the John Fritz Medal in the larger life of the twentieth century engineer? Methinks I see in that reflection the outlines of a magnificent building, the capitol of American engineering. Into this home situated in the metropolis of the nation are gathered the great engineering societies from their scattered lodgings. Here is a great technical library; here are ample assembly halls and comfortable parlors; here are the headquarters of a score of lesser societies, restricted in their scope, but affiliated in their work. I see all over the country innumerable local societies and engineering clubs, no longer isolated, but joined together into one great combination. I see them affiliated with the national bodies of the several professions—sometimes as local chapters—all together constituting a great union. There is individual freedom, but general co-operation. Representing all the engineering professions and supported by the great union of the national engineering societies, I see an Engineering Congress at the head, giving to engineers a rank consistent with the importance of their work and increasing the efficiency of the interrelations among its members. An eminent body,

it is powerful in advancing the common interests of engineers, and it represents the engineering profession in its relation to other professions, to pure science, to education, to legislation, to public improvements, and to the general welfare.

Years ago engineers were individuals of trivial consequence compared with men in the learned professions. Now they too form a profession of recognized importance. But as yet the national societies of this profession, which has made the nineteenth century an era in the world's history, which has provided the means for the production of unmeasured wealth, and which promises yet greater things for the future, have not even adequate homes of their own. Within the present week the Society of Mechanical Engineers, which has a little house of its own, found it so very little that it was forced to hold its meetings in a large room in a nearby tavern. There were present men through whose work hundreds of millions have been added to the wealth of this country, and their present efforts are to increase the efficiency of the future. (Applause.) Is this right? Is it just?

But may not the fault lie somewhat with the engineers themselves? Have they fully recognized their own strength and importance? Have they shown a disposition to act together, to do large work in a large way? Have they given promise that they would use the enlarged facilities in such a way as to increase the efficiency of engineering work?

The men who are mastering the powers of nature will yet rise in the strength of united effort to meet the increasing responsibilities of the coming years. For it is theirs to build the foundation of the new civilization; it is theirs to establish that material prosperity which is the underlying condition of broader, higher, and fuller life.

The end of engineering is usefulness; the characteristic of America is activity; the modern method is co-operation. As Engineers of the Twentieth Century, let us be useful; let us be active; let us co-operate. (Cheers and applause.)

Mr. Dodge: Gentlemen, you will now take pleasure in hearing the President of the American Cement Company tell us how to cement our friendship with the bonds of commerce. I take pleasure in introducing to you Mr. Robert W. Lesley.

Mr. Robert W. Lesley: Mr. Toastmaster, our guests, and fellow-members: When I received the invitation from our worthy chairman to reply to the toast of "Commerce," I thought at first it was quite an easy thing. On second examination it brought to my mind forthwith a very old story. There were once two little alley girls who

strolled from the alley and stopped in front of a drug store. All over the windows of the drug store were sponges, and some were strung on strings outside of the drug store. The little girls looked at these sponges and one said to the other: "My! Mary! Would you ever think there were that many slates in the world?" When I got this small, easy, light contract, and a time limit of five minutes to tell it in, I began to wonder how many kinds of commerce there were in the world. Commerce by sea, commerce by land, commerce by canal boats, commerce by roads, every kind of commerce; and what kind of commerce a body of engineers was supposed to take most interest in your worthy chairman left for me to guess.

However, overwhelmed with the great responsibility, I said "Croton"—which I understand is the biggest dam known to the engineering profession; and once rid of that engineering cussword, things seemed to be a little easier, and after that it all seemed to me that the best kind of a way to talk about commerce to a body of engineers was to drag them in themselves and show them what kind of fellows they are in the field of trade. It seemed quite an easy proposition then.

The engineer has always had a hand in commerce. Without him commerce would be impossible; but the distinction between the engineer's relation to commerce in our time and in antiquity is a most interesting one.

When we look back to Rome and to the great works that stood in the days of the ancients, to the bridges and waterworks, we find that the engineer was almost a part of the war machine. We find that his work was done with slaves at the direction of the general. We find that while his works contributed to the commerce of the world, the real producer of the commerce of antiquity was the warrior, who first conquered and killed a great number of his prospective customers and made the balance buy his goods.

Coming even to more modern times, we find the engineer building the great roads for Napoleon, but the great roads were built not primarily for commerce, but for war; commerce again following the warrior through the intermediary of the engineer, and again the same old proposition: the killing of many men and the securing of the residue for customers.

In our time the engineer, in his relation to commerce, is not the index to a war department. The engineer is the corner-stone of commerce. In our day the whole center of gravity, of commerce, is dependent upon its engineering ability and engineering talent.

We need only look about us to see England with Davy, Watt, and Stephenson—the development of coal mining, the development of the railroad, and the development of the steam engine—commercial supremacy due to England's engineering talent.

Commerce follows the work of the engineer, and the great commercial nations have developed concurrently with their engineering ability. This is at the base of England's growth. It is at the base of Germany's progress. Coming to our own time and our own country, the same truth prevails.

It is useless to stay here and discuss before a body of men such as this, familiar with every branch of the profession, how many miles of railroad this country has built, to discuss with you how many times the carload has been increased, to discuss how much the power of the locomotive has been increased. Nor is it necessary to talk of the telegraph, the telephone, and the trolley. All this is familiar news to you. What would it be without the engineering talent of our engineering friends that makes this great commercial success possible? It would seem as if every single progressive step in our present period is blessed by the engineering talent that makes it possible and brings to earth in solid fact the biggest rainbows of the theoretical dreamer.

It is useless to go into the commercial statistics as to the growth of commerce in this country, or as to how much of that growth is the direct production of the engineering brain of the United States. These figures can be had in the encyclopedia, but one big set of figures has just come out which bears directly upon the facts that I have been speaking upon, and that is that the very last statistics of the bureau in Washington show that, in the last ten months, for the first time the products of manufactures have very nearly overtaken the products of the field in the exports of our country. Heretofore they were about one-third and to-day they are over 40 per cent. It is needless to say that in time, if American engineering ability can by successful and economical modes of manufacture produce so cheaply as to enable manufactured goods to represent 50 per cent. of our total export of field, farm, and mill, they will have opened up a large commercial proposition.

One thought more and I am done. In these days of great commercial prosperity and great wealth, we are all likely to be a little skeptical as to the enduring conditions, and to wonder after all whether it would not be better to have less money in outside ventures and a little more in the stocking. To this the answer would seem to me, that

this country supplies the fuel for the human machine in the shape of the cheapest food products in the world. It supplies the fuel for the inanimate machine in the shape of the cheapest coal anywhere to be found.

Given these two essentials, and add to them the engineering ability to furnish the spark of genius to transform this fuel into power, this country has the greatest supply of power of any of the countries of the world.

Power is commerce, and commerce is power. (Applause.)

Mr. Dodge: Gentlemen: For responding to the toast of "Engineering and Our Kindred Societies," I congratulate our Committee (I had nothing to do with that part of the program) in making the selection of a past-President of The Engineers' Club of Philadelphia and the present efficient President of the Franklin Institute. I have pleasure in introducing Mr. John Birkinbine.

Mr. John Birkinbine: Mr. Chairman, guests, and fellow-members of The Engineers' Club: (I mean Mr. President. Mr. Hartley, if you will please sidetrack the Duke of Nicetown for a moment I would like to address myself to you). (Laughter.) Can I offer a better response to that toast than to point to this assemblage and ask you to look back ten years, when you, with other members of the Board over which I then had the honor to preside, found a Club so nearly bankrupt that we considered asking our friend General Wagner to reduce the rent of our Club house; when, if you had proposed a dinner at fifty cents a head, you would not have had over twenty-five men to attend it? Can I respond, then, better than to point to this meeting? That is one reason I asked to speak to you, sir. But another reason is that I want to respond for some organizations of which I am a member. Now, I do not claim membership in all engineering societies, but I find that considerable money goes annually into these American societies; one is the American Society of Mining Engineers; another is the American Society of Mechanical Engineers. And I say to Mr. Hartley that you have for your Toastmaster to-night a man that this week presided over six hundred members of the American Society of Mechanical Engineers and was elected its President. (Cheers.) It is not merely the Duke of Nicetown now; it is James Mapes Dodge, President of the American Society of Mechanical Engineers. I propose the health of President Dodge, of the American Society of Mechanical Engineers. (Three cheers.)

Mr. Dodge: Thank you, gentlemen.

Mr. Birkinbine: My reference to the troublesome times which we passed is to make us all feel gratified that we meet together to-night as we are, united and strong. I shall not quote that old saying about the tide which, if taken at the flood, leads on to success. I mentioned two of our great national societies. I might speak for the American Society of Civil Engineers, but not with Schermerhorn, Webster, and others present much better able to respond. I merely call attention to the fact that last week a number of us stood at the bier of one of our formerly active members—I mean Mr. Joseph M. Wilson, who was prominent in the American Society of Civil Engineers.

Mr. Scott has already spoken for the American Institute of Electrical Engineers. All of these national societies are represented in our membership.

I might also speak of the uncivil and unmechanical engineer, like our friend Mr. Fritz, who will admit that ten years ago I was his prosecutor in a burlesque suit brought against him for claiming to be an engineer when he had not an engineering education. We put on the stand men who swore (in their own way) that Fritz had in his early life ridden a horse on the canal towpath, bareback, and the attorneys on the other side claimed a defect in our "narr" because we failed to say whether the man or horse was bareback. (Laughter.)

Reliable witnesses that lived in that valley for years testified that this man first took a beautiful orchard (where the boys stole the apples) and converted it into a great industry which disturbed the people who wanted to be good in Bethlehem, and so last month, when he was through his ten years' service, he celebrated it by a dinner in New York.*

I might speak for the organization over which I now preside—the old Franklin Institute. There is an organization that has been trying for years to prove to the people of Philadelphia and elsewhere that a good name is better to be chosen than great riches. (Laughter.) Desiring to hear what the other speakers have to say, I wish merely, in closing, a word or two with you who have been my friends and associates in The Engineers' Club. You will go out from this meeting to-night, every one gratified, pleased, and proud, because the Club has accomplished something, because it is united and it is standing together with one purpose. It will be your duty and mine to see that this same

* This refers to the celebration of Mr. Fritz's seventieth and eighty-third birthdays by his engineer friends.

condition continues and that we work together harmoniously. If we work together, do all we can to advance the engineering profession, standing true to it, then The Engineers' Club will have another dinner as good as to-night. (Applause.)

Mr. Dodge: Gentlemen, we will now take pleasure in hearing Professor Goodspeed respond to the toast of "Our University." This is put on the list because so many members of The Engineers' Club, and the engineering profession who are not here to-night, are beholden to the University of Pennsylvania for their start in engineering. I take pleasure in introducing Professor Goodspeed.

Professor Arthur W. Goodspeed: Mr. Toastmaster and gentlemen (including the engineers and guests): The differentiation of the company present made by the second speaker, Mr. Smith, reminds me of an early experience which Professor McMaster had at the University of Pennsylvania. As many of you know, it is customary with a new professor for the students to see what he is made of. It was Professor McMaster's first recitation at the University. As was customary, I suppose, he asked his pupils to close their books. His remark was, "Gentlemen will now close their books." They paid very little attention to the request. A few did. He waited a moment and then remarked: "Now those of us who are not gentlemen will please close ours." It was not necessary for Professor McMaster to impress upon the boys what he was made of after that. He is a small man (like myself), with a large head—very much larger than mine in every respect.

As you see, Mr. Smith's remarks are proving very profitable to me this evening. His reference to the supposed slowness of Philadelphia reminds me of an experience that I myself had this fall, which convinced me, even if I had supposed it before, that Philadelphia is not so slow—at least comparatively. I came here myself from Boston (I believe Boston has been referred to this evening as sending out only smart men) some time ago, and it was supposed at that time that people in Philadelphia were rather slow. I may say that I have since had many opportunities of fixing that wrong impression up Boston way. I had some professional business in a neighboring city, not to mention names (it is about a hundred miles west of us). The occasion of my visit is not important to the story, however. It was about half-past eleven in the forenoon, when it is supposed that the business of a town, if it has any, is at its height. I made my way to the Board of Trade building, where I was to spend the day. The door was open.

I wandered around (no one was about) until I met an expressman with a package. He was coming out, having found no one to leave the package with. I questioned him and found he could give no information. I wandered about the building myself and met with no signs of life. Finally, having attended to my business as far as possible alone, I began the hunt again. After some time I found the janitor in the basement, asleep. Having wakened him and come upstairs, we met the Secretary of the Board of Trade coming in. I made some remark about the inactivity of the place at that time of day, to which he made some comment that I do not remember. I said: "Perhaps we are slow in Philadelphia—I think we are and even die sometimes, but the neighbors do get around and put crêpe on the door. Up here you can die and nobody ever knows it."

All this, perhaps, has little to do with the University of Pennsylvania. In the absence of Provost Harrison, whose place I am told I am supposed to take this evening, I find myself accepting a double honor, though I am quite certain that I cannot, even in a semi-acceptable way, change places with the Provost of the University; again, that I have been asked to speak on the broad subject of "Our University," and allotted only five minutes for the purpose, is indeed evidence on the part of somebody of his high opinion of my ability as a sleight-of-tongue performer.

My connection with the University is of eighteen years' standing, and in that period I have seen it increase in size about threefold, while in importance, I am sure, the increase has been many times that. I had recently graduated from Harvard, and had heard through Professor Trowbridge of a vacancy here in the department of physics. I thanked him for the suggestion and asked him where the University of Pennsylvania could be. I was not sure, although I presumed it was in Philadelphia. To make certain, I went into the Harvard College Library and looked about for some one who could tell me, and it was only after finding a catalogue that an attendant assured me it was in Philadelphia. However, the ignorance on the part of the Harvard College people in regard to the location of the University is well matched, as was evidenced a year or two later, after I came to Philadelphia, when, one evening, in conversation with a lady who asked me where I graduated, I said, "From Harvard College." She looked at me and said: "Harvard College? I have heard of that; where is it?" However, the University of Pennsylvania and Harvard College have both become better known, mutually and

otherwise, since then, and the growth of the latter, of course, you are very familiar with.

I am gratified to see here many faces that I have seen before—men who have been through the engineering schools at the University and have taken the course in physics, much to their disgust at the time, but I hope gratification since.

There are in progress at the present time several important enterprises.

The new laboratories for the Department of Medicine, already far advanced toward completion, to cost $600,000 or thereabouts; the new Franklin Field with its grand gymnasium, sure to take a place *ahead* of the front rank, to cost a half million or more, preliminary work on which has already begun; the new Engineering Laboratories, to cost about $350,000, to occupy the site east of the Randal Morgan Laboratory of Physics, and for which I am assured by the Provost ground will be broken within the next six months, comprise three pieces of work of great value and importance to the immediate reputation of our institution. The Department of Engineering will soon be equipped to handle 500 students at a time.

In regard to my own subject, the subject of physics, many of you are aware that we have made a change in the last two or three years, in moving the department from College Hall into a new home—the first step in making use of the very generous gift of one of our trustees and graduates, Mr. Randal Morgan. We moved into the present Randal Morgan Laboratory of Physics—the building just north of the Hygiene Laboratory—two years ago, with the supposition that it would be large enough to suit our purposes probably for five years. It was gratifying this morning to tell the Provost that it was absolutely necessary to consider very quickly what must be done with the department of physics during the next two years. In that time it would be absolutely impossible to live and do business in our present quarters. He assured me that the matter would be brought to the attention of Mr. Morgan and those interested in the matter at once. We shall meet a problem which I have heard many of you say impossible, that is, in solving how two bodies can occupy the same place at the same time,—impenetrability of matter,—for the site of the new Physical Laboratory, the ultimate physical laboratory and home for the department of physics, is to be where we are now located, and cover also the ground immediately north of that and west of the ground to be occupied by the new Engineering Laboratory. How can the

department of physics go on with its work in the year or year and a half that the new laboratory is being erected, is what we shall have to solve; but it will be solved, and we shall do it. We can probably build walls around our present quarters, including the two buildings, and then throw the old buildings out of the windows.

That definite action must be taken at once is evidenced by the increased demands upon our room and staff even during the last year, the total number of student hours having increased about 33 per cent., while the number of students taking practical laboratory work has increased about 100 per cent.

I thank you, gentlemen, for the pleasure of meeting with you to-night, and I only wish I myself were an engineer. (The auditors then gave the Pennsylvania College Yell.)

Mr. Dodge: The response to the toast "Our Founders" will be made by one of them, and I take pleasure in introducing to you our mental and physical Hercules, Mr. Wilfred Lewis. (Laughter.)

Mr. Wilfred Lewis: Mr. Toastmaster and gentlemen: Everything must have a beginning, consequently The Engineers' Club of Philadelphia had founders; and when the survivors of that little group of young men look at the Club as it stands to-day, one of the flourishing institutions of the city and State, with representatives in all parts of the globe, who give life and interest to its proceedings, and reflect credit upon the community in which it abides, their hearts are justly stirred with pride.

Between the social gatherings that were formed in 1877 and the Club of to-day an advance has been made commensurate with the progress of the age in the last quarter of the nineteenth century. And yet the founders are only to a small extent identified with the growth and prosperity of the Club, for in the beginning the membership was limited to fifty, and nothing more than social reunions, at which professional papers might be introduced, was contemplated. The credit chiefly belongs to the new blood which has constantly come to the aid of the old and has given by its energy a new impetus and a new interest in club affairs.

The founders were, with one or two exceptions, young men just out of college, striving to find chinks in the blank wall of industry on which to place their feet and begin to climb. They felt lonesome or disheartened, perhaps, as they looked up at the dizzy heights attained by their predecessors, but they had the strength and ambition of youth—that potential capital, not measured by dollars and cents,

which moves the world. Each was striving in his own way to achieve something, and each knew there were others like himself laboring in the same or similar fields of engineering work. Congenial spirits occasionally or accidentally came together and compared notes, and they naturally felt the advantages of an interchange of experiences; but there was no tent in Philadelphia under which they could call their brothers and be at home. Misery loves company and so do engineers. When they have nothing else in sight, they like to see each other. It is comforting, consoling, and no less enlightening, for by the cheerful lamp of companionship the best that is in us comes to the surface, to be seen or heard and appreciated.

Some time in the fall of 1877, a few young men, residing mainly in West Philadelphia, of whom I believe our first secretary, Mr. Chas. Billin, was the leading spirit, conceived the idea of organizing a little group of engineers, to meet from month to month at the homes of its members. The suggestion met with a hearty response, and after two or three preliminary meetings had taken place, a formal meeting for organization was called in December, at the home of Dr. Coleman Sellers. At this meeting there were nineteen attendants, who enrolled themselves as members. Professor Haupt was chosen President, Coleman Sellers, Jr., Vice-President, and Charles E. Billin, Secretary, and The Engineers' Club of Philadelphia was thus formally launched. The dues, if any were fixed at this time, were merely nominal; but each member was expected to exercise his privilege of entertaining the Club, and for a time there was quite a rivalry among applicants for that honor. A simple repast, not exceeding the limitations imposed here to-night, was served at each meeting after the reading and discussion of such papers as might be offered, in default of which extracts from leading journals or periodicals were in order; but the social feature was predominant, and a dearth of professional papers was in those days borne with equanimity. But the Club soon doubled in numbers, and before all of its founders had an opportunity to extend their hospitality, private houses became inadequate for its accommodation. A room was then rented on West Penn Square where the Broad Street Station now stands. These modest quarters on the third floor were the arena of many interesting debates, but their very limited dimensions tended to check the social feature, and for a time I think the Club ceased to grow. It then found more attractive quarters on Chestnut Street above Broad, and migrated up and down that thoroughfare for several years, until it finally

acquired sufficient strength to claim a house and home of its own in the comfortable quarters which it now occupies on Girard Street.

It is now of age and can stand alone without any support from its founders, but those who remain are still alive to its welfare, and from the interest manifested on this auspicious occasion, I feel sure that the time is not far distant when the Club will rejoice in larger and better things than it has yet enjoyed. New aspirations follow close upon the heels of success, and the laudable desire to own a home befitting the dignity of the engineers of Philadelphia will, I trust, press on to achievement.

I cannot attempt to sketch, within the limited time at my disposal, a history of the little group of whom I have been asked to speak. Of the original nineteen members, one of the most active workers, Chas. A. Ashburner, who won distinction in his brief career as a geologist, died in 1889. Another, Edward Nichols, who became President of the Brooks Locomotive Works, died in 1892, after serious injuries received in a hotel fire. The others, so far as I know, are still living, but I have been shocked to find that out of these seventeen only four still retain their membership in the Club. Evidently the Club has long since ceased to lean heavily upon its founders, and I think I can say that since its organization in 1877, the founders, as such, have never met or flocked together. They have met simply as club members without any thought or desire of forming a clique within it, and the success of the Club is, I believe, in some measure due to the free and democratic spirit that has always pervaded it. That its growth and prosperity may continue unabated, and that its influence may expand as a power for good in the community, is, I am sure, the wish of the founders, and particularly the wish of those who still stand by the ship that they launched in 1877. She has weathered many storms and shows that her founders "builded better than they knew." (Applause.)

Mr. Dodge: Gentlemen: The last potent factor to dispel the fog of secrecy, and which has brought engineering together on a common ground by telling each one of the work of the others, is "The Technical Press," and to this toast we will hear a response from Mr. Trautwine.

Mr. John C. Trautwine, Jr.: Mr. President and Mr. Chairman: Apropos of "The Technical Press," it gives me great pleasure to express my thanks to that veteran of engineering literature, Mr. Charles H. Haswell, and my appreciation of his kind reference, in his letter

read here this evening, to the work of that other veteran in the same field, my father.

In celebrating the silver anniversary of The Engineers' Club of Philadelphia, it is only proper that the technical press should come in for honorable mention; for there is probably no single engineering society, of the size of our Club, which has ever maintained, unaided, a more highly and uniformly creditable journal than are our Proceedings.

But, with all respect to the wisdom of Mr. Dodge's committee, I submit that it might have done better than by selecting, for this toast, a man who, after nearly eighteen years of membership, is only now preparing his first formal paper for publication in that particular member of the technical press.

Epigrams generally depend upon their audacity for the effect which they are intended to produce; as when we say that "an ounce of prevention is better than a pound of cure." And so, when we read that "beneath the rule of men entirely great, the pen is mightier than the sword," we instinctively contrast the puny pen, which a child may wield, and the chief use of which is to soil good paper, with the mighty sword, with which shrewd kings subdue their silly people.

Man is a lazy animal, especially when it comes to using his gray matter; and he finds it easier to realize something of the grandeur of great engineering constructions, than to comprehend the far greater grandeur of the real basis of those works—the invisible but underlying thought, expressible in words by the technical press.

In olden times the word-monger, by his rarity, formed a class apart, and his ability to write his name was recognized as a feat not to be attempted by the common herd. And yet his miraculous proficiency seems to have conferred upon him but little of dignity. He remained an inferior, occupying about the same rank, in the estimation of his betters, with those other jugglers who performed the equally startling feats of swallowing snakes and other such trifles.

But evolution works strange revolutions, and often brings forward the weak things of this world to confound the mighty; and so, notwithstanding the stupendous advances made in what are sometimes regarded as the more active branches of engineering, the technical press has in general maintained its place in the procession; and the technical editor, while he may not amass the colossal fortune of the successful manufacturer, or speculator, or statesman, has at least,

during the last quarter century, strengthened his position relatively to his colleagues in the constructive branches of the profession.

But if this be true for the last quarter century, what shall we expect from the next? The diagram of progress is not a straight line, but a curve, concave upward; and we may safely prophesy that the advance of the technical press during the next twenty-five years will be such that, by contrast, all our boasted progress of the last twenty-five will appear to have been no progress at all.

I have here an interesting specimen of the early product of the technical press, a copy of the "Journal of the Franklin Institute" for August, 1831, and in this I find an advertisement stating that "Matthias W. Baldwin, Machinist and Engraver, 14 Minor Street, Philadelphia, respectfully informs the public that he continues to engrave Cylinders for Calico Printing. He has also recently commenced cutting screws of wrought or cast iron, of superior workmanship, suitable for all kinds of heavy pressing."

In the same journal for August, 1834, Mr. Baldwin announces that he "is now prepared to execute at the shortest notice, orders for STEAM ENGINES, LOCOMOTIVE OR STATIONARY, of any power, specimens of which may be seen in operation."

When I last sat in this room of patriotic memories, it was to aid in celebrating the seventieth anniversary of the foundation of the Baldwin Locomotive Works; and, as I listened to the eminently proper eulogies of those works, of the acreage which they cover, of the thousands of their employees, of the twenty thousand locomotives built there, which, with their tenders, would reach from here to Altoona, I knew that what we were really celebrating was not so much any of these great things as it was the greater thought which, away back in 1831, was shaping itself in the brain of Matthias W. Baldwin, as he turned out his Cylinders for Calico Printing, in his little shop at 14 Minor Street, Philadelphia.

It is the engineer's *thought* which "directs the great forces of nature to the use and convenience of man"; and it is the high mission of the technical press, not only to give to this thought a thousand tongues, carrying it to the ends of the civilized world, and far beyond, to the lone engineer, toiling in the far east, or in the far west, or in those Pacific islands where the east and the west are said to meet; but also, after the thought has found its incarnation in actual construction, to show that construction to those who have already been made familiar with the thought.

No one who is at all familiar with the technical press of to-day, and who stops to compare it with that of a quarter century ago, need be told of the advances which it has made during that time; and yet it has lagged behind the procession in one very important respect. I mean that tendency to consolidation and unification which forms perhaps the most conspicuous, the most remarkable, and the most portentous feature of our modern industrial life.

While railroad and steamship lines and steel works are rushing together like the kindred raindrops upon a window pane, the mails and our desks continue to be overburdened with a legion of publications, issued both by technical societies and as business enterprises. The same ground is threshed over and over by competing publications in one and the same narrow field; a given paper is printed and reprinted and abstracted *ad nauseum;* and the task of referring to a given subject, in this mass of literature, would be quite hopeless, were it not for the fortunate advent of that comparatively recent acquisition to the ranks of the technical press, the technical index, which, in a measure, furnishes a remedy for the evils inherent in this state of things.

Yet some notable effort has been made in the direction of better organization of the technical press, and in the history of this effort stands out conspicuously the name of that born organizer, the late Arthur M. Wellington, who was prominently active in all three of the departments of the technical press; first, as author of "The Economic Theory of the Location of Railways"; second, as one of the editors of "Engineering News"; and last, but not least, as one of the founders, if not indeed the father, of the Association of Engineering Societies, which, organized in 1881, now numbers eleven societies, including those of Boston, San Francisco, Montana, New Orleans, St. Louis, Cleveland, Detroit, and Buffalo, aggregating about 1600 members, and which gives to the profession a single strong monthly, in place of half a dozen or more of struggling annuals or quarterlies.

For eight years, as Secretary of the Association of Engineering Societies, I have held our parlor door wide open, and have been constant, in season (and possibly at times out of season), in trying to induce the Engineers' Club of Philadelphia and the Engineers' Society of Western Pennsylvania, two of the three great societies still outstanding, to walk in. I have felt that it might be considered an abuse of the Committee's kindness in entrusting me with the response to this toast, if I were at this time to reopen this question, which has

already been raised at least twice, and each time settled in the negative; but the eloquent appeal made to you this evening by Mr. Scott, the President of the Engineers' Society of Western Pennsylvania, in behalf of "co-operation versus clannishness," has silenced these compunctions. I am but seconding his appeal for "co-operation versus clannishness" when I say again, to The Engineers' Club of Philadelphia and to the Engineers' Society of Western Pennsylvania, in the words of the President of the latter society: "Let us co-operate." Let us get together. Bring your separate publications into the fold of the great and only Association of Engineering Societies. Let there be no break of gage at Pittsburg or at Philadelphia.

Who knows but that we might then hope to win back, into the same fold, the erring and late lamented Western Society of Engineers, represented here this evening by Mr. Emil Gerber, who earnestly strove for continued co-operation by opposing the withdrawal of that Society from the Association, when, fired by the success of the World's Fair in 1893, it fell an unhappy victim of the "world-power" mania?

With these three great societies in the Association, the membership of the latter will be nearly doubled, and its journal will assuredly command the subscription of every prominent engineer in the United States, relieving the societies of any expense for publication.

It will then be in order to move upon the citadels of the four great national engineering societies, and, after their conquest, to proceed to the capture of the British societies and institutions. With that result attained, the knowledge of engineering shall cover the earth as the waters cover the sea.

Mr. Dodge: Gentlemen, one word before we part. I want to voice the feeling of all the members of The Engineers' Club of Philadelphia in thanking Mr. George T. Gwilliam for his able and efficient work in organizing the arrangement of this banquet. (Cheers.)

We are indebted to the courtesy of the Union League Club of Philadelphia for having the privilege of using this room and also enjoying their sympathy; therefore call upon Mr. Boyd, the representative of the Union League, to speak a few words to us.

Mr. Peter Boyd: Mr. Toastmaster and gentlemen: I am very much reminded this evening of a dinner that a Scotchman gave to an English friend. One of the dishes was an old-fashioned hodgepodge, which seems to have been somewhat of a mixture or conglomeration of everything under the sun. The Englishman was very much pleased with the combination and said: "How is this made? What is in it?"

The Scotchman replied: "There is carrot intil't, beans intil't, leeks intil't." "Yes, yes," said the Englishman, "but what is 'intil't'?" I have listened to these wonderful speeches to-night from gentlemen representing every department of engineering and I have at last come to feel that I am as ignorant of the true definition of an engineer as the Englishman was of the Scotch phrase "intil't." If some one will give a clear, concise definition that will include the men who used to run the fire engines when we were boys, as well as the mighty ones of to-day, who throw out bridges and construct great works, we would all, I think, be somewhat wiser.

You are to be congratulated, gentlemen, for many reasons, on this your silver anniversary, not the least of which is the five minutes' limit that your toastmaster has imposed upon every speaker, although I might say that this wise regulation has been somewhat honored in the breach rather than in the observance. The toast you have just pledged, however, is one that might well be responded to in much less time.

To those who know the Union League—and its admirers believe that its fame is world-wide—the sweet cadence of its name speaks more eloquently for all that it stands for than the words of any one could possibly do, however gifted he might be. Its devoted members cherish that beloved name as they cherish their most valued possessions, and when they hear it uttered by the lips of strangers in tones of endearment or praise, their emotions are stirred as if by the magic spell of some old and familiar song or the fragrance of a half-forgotten flower that comes stealing over the senses with memories of glad and distant days. There was a time when that name was as a trumpet-call and an inspiration to the whole people of the Northern States, and the remembrance of that day has not yet faded out nor been forgotten. Those who know its history best do not look upon the League as a club, although it gives to its members the enjoyments and privileges of the best of clubs. They love to look upon it as an institution of national renown, as the embodiment of a living vital thought, as the outward expression of a deep and impelling faith. The thought that lay nearest to the heart of the fathers in the beginning of its days was the perpetual and irreducible union of the States, and the faith that upheld them was that in the preservation of that Union lay the hope not only of the nation, but of humanity itself. And so they linked themselves together in a league of hearts with one common purpose and one common vow in the days when the life of that Union was

imperiled by foes within as well as by foes without. Throughout its honored years it has ever been consistent in advocating those principles and measures that have made for the upbuilding of the nation at home and abroad, and it is simply matter of common history that when those principles have been the directing force in the counsels at Washington, the problems that the people have been called upon to solve have been problems springing from abounding prosperity; and when those principles have been departed from, the problems have been those of depression and despair. It has lived to see this nation become so great in all that makes for national greatness that when the battle fleets of Spain came sailing to the West a year or two ago, it was to discover again a new world far beyond the dream of the old. And when the survivors of that ill-fated fleet went back to the East, Europe was filled with amazement at the strange reports they brought, so that ever since kings have vied with each other in striving to become our allies, and princes have sought our borders only to find that the half had not been told. (Cheers.)

The League has, therefore, lived to see the faith of its founders more than justified and to behold this nation fast becoming the center of the world. Born like that nation itself amid the shock and conflict of battle, its lullaby was sung to the booming of cannon; its first steps were timed to the rhythmic march of armed men, and in its earliest years it learned the meaning of death and of glorious martyrdom as it followed to the grave the form of the greatest Commoner of all historic time. Is it strange, therefore, that it should seek to have for its children only those who have the feel of iron in their blood, or that it should demand of those who would become its sons loyalty and unfeigned devotion to the faith that gave it birth? May its light never grow dim! And if in the fate of nations it must needs be that war shall come, may it ever be then, as it was in the past, a glorious inspiration; even as it is to-day, in the times of peace, a benediction to all who are privileged to come within its walls. (Cheers and applause.)

Mr. Dodge: Gentlemen, before we part let us toast the health of our honored guests and all the prosperity and future welfare of The Engineers' Club of Philadelphia.

Mr. Dodge (after the toast): Here are the flowers. Don't forget the ladies, gentlemen.

FIRE MAINS.*

JOHN C. TRAUTWINE, JR.

October 4, 1902.

In the process of evolution, we often find members and systems apparently outliving their usefulness. This will be recognized as true respecting well-known portions of our anatomy and of our clothing. Another instance is to be seen in warfare, which continues in vogue to some extent notwithstanding that the efficiency of modern methods of settling international disputes has been thoroughly demonstrated.

In the matter of water-supply, also, we find many towns and cities persisting in the ancient practice of pumping oceans of water in excess of their legitimate needs and luxuries, notwithstanding that their neighbors have found a scientific, just, and satisfactory remedy for this absurd state of affairs.

The impress of the ancient stage-coach is still to be seen in the form and arrangement of the modern European railway carriage, notwithstanding the superior advantages of the American system with its departure from that form.

* The writer takes much pleasure in making acknowledgment, for valuable information and illustrations, respecting the Philadelphia system, to Messrs. F. L. Hand, Chief, and John E. Codman, Chief Draftsman, Bureau of Water; to Mr. John W. Weaver, of the same Bureau, in charge of the work on the Philadelphia fire pipe line system; to the Hoffmann Engineering Company, contractors for most of the work; to Messrs. C. A. Hexamer and Herbert Wilmerding, of the Philadelphia Fire Underwriters' Association; and to Messrs. James C. Baxter, Jr., and John C. Sager, Chiefs of the Fire and Electrical Bureaus respectively. For information respecting other systems, the writer is indebted to Mr. M. W. Kingsley, late Superintendent of Waterworks, and Mr. R. J. Reichert, Superintendent of Machinery, Department of Fire, Cleveland; to Mr. G. H. Benzenberg, late City Engineer, and Mr. B. W. Perrigo, Assistant City Engineer, Milwaukee; to Mr. Clarence W. Hubbell, Civil Engineer to Board of Water Commissioners, Mr. D. W. Carroll, Superintendent of Water for Fire Department, and Mr. Eugene H. Sloman, of Detroit; to Mr. Louis H. Knapp, of Buffalo; to Mr. Edmund B. Weston, of Providence; to Mr. Frank A. McInnes, Assistant Engineer, City Engineering Department, Boston; to Mr. O. Chanute, Mr. John Ericson, City Engineer, and Mr. W. H. Musham, Fire Marshal, Chicago; and to Mr. Foster Crowell, New York.

And so in the matter of fire extinction, the adoption of the old hand fire engine, leading up, as it did, to the modern steam fire engine, has probably delayed somewhat the introduction of improved methods, it having been taken for granted that a vehicle, hauled to the scene of conflagration, was a necessary part of the outfit.

Something like a quarter of a century ago, the now well-known Holly system introduced an innovation in this respect, giving a combined low-pressure water-supply and high-pressure fire service system, both operated by the same stationary engines, which drew their water from the source of supply in river, lake, or well, as the case might be, and dispensing with the use of movable fire engines.

The system now under consideration differs, however, from the Holly system in that its pumps and mains are used exclusively for fire extinction, even though, as in Providence and in Philadelphia, they may not be entirely disconnected from the mains and pumps used for the water-supply.

A great advantage of the fire main system is that it enables enormous volumes of water, under high pressure, to be thrown upon the fire with great promptness.

Compared with the large and powerful streams from the modern fire main, the small and relatively weak streams thrown by steam fire engines are quite inefficient.

In Buffalo, the saving, in the first fire which occurred after the installation of the fire main system, more than paid the cost of that system, and it was found that one good 2-inch stream was worth more than a dozen small streams from steam fire engines.

I quote as follows from a paper entitled "What a Water-supply Engineer Can Do in the Fire Department," by James E. Tryon, Secretary of the Fire Commission, Detroit, Mich., read before the New England Waterworks Association, at Boston, in June, 1894:

"The burning of the great dry-goods store of Edson, Moore & Co., in November, 1893, was, without doubt, the most disastrous fire that ever occurred in our city. The flames were first discovered on the fifth or upper floor of the building occupied by this firm. The fire originated by a lighted cigar stub communicating with a bale of cotton batting, the fire then jumping from one bale to another with as much rapidity as it ignites the impalpable dust of a flour mill.

"When the alarm was given for this fire, the flames were bursting through the roof, and, before a stream of water could be directed into the building, the roof had fallen, and the inclosing walls had

begun to fall. The fire-boat "Detroiter" responded to this alarm, and, by means of the pipe lines, sent four $1\frac{3}{4}$-inch and one 2-inch streams into the burning structure. These streams were of the kind which make a black mark wherever they strike. Men who are accustomed to attend fires unite in the belief that, but for the big streams thrown by the "Detroiter," there is no telling where the fire would have stopped. In one and one-half hours the immense building was a heap of smouldering ruins, and the fire had not only been confined to the building where it originated, but it had been prevented from crossing a twenty-foot alley and communicating with one of the greatest chewing tobacco factories in the West, and the secret of it all is that the pipe line enabled the boat to deliver these immense streams that made the craft equal to a dozen steamers of the largest size."

The Providence system paid for itself by the saving which it effected during one fire in the summer of 1897. Insurance rates were reduced 5 per cent., and the policy-holders will save, in premiums, in ten years, more than the cost of the system.

For years the water fronts of many of our large cities have been protected by fire-boats, stationed along the water fronts; but, owing to the friction in long lines of hose, the radius of activity of these boats is limited pretty strictly to the water fronts themselves. By means of the fire main, that radius may be extended inland almost indefinitely, and in this way the fire-boats, which otherwise would be idle most of their time, may be called into service more frequently.

An incidental advantage of the separate fire main is its effect upon the water-supply.

It is true that the total amount of water, consumed in a large city for fire extinction during the year, is much less than is ordinarily supposed; but the great conflagration entails, for a short time, a heavy rate of draft upon the water-supply system, which must, therefore, either be designed with dimensions unnecessary for its legitimate functions or must be found unequal to the combined demands of both its offices when these occur at the same time; and this difficulty is apt to be most seriously felt in the older sections of our large cities, where business is most active and disastrous fires most frequent, and where the water-supply pipes, of small diameter as originally laid, are often found with their carrying capacity seriously reduced by internal incrustations.

Another incidental advantage of the fire main, with its heavy

pressure, is its efficiency as a means for cleansing sewers, gutters, and street surfaces.

Those water-supply experts who are fond of clamoring for "water as free as air" are apt to lay stress upon the advantage, from a sanitary point of view, of having rivers of wasted water flow gently through the sewers; but any one at all acquainted with the relation between velocity and scouring effect will recognize that such rivers are quite inefficient when compared with a well-directed stream discharged against the walls or bottom of a sewer under such pressures as may readily be maintained in a fire main.

Ordinarily, any source of water-supply, however impure, will suffice for the purposes of fire extinction.

The most conspicuous example of the use of fire mains is that which is to-day afforded by our own city, which has probably the most complete system in existence, a system which is still further to be perfected by the establishment of a large pumping station; and we shall, therefore, naturally direct our attention chiefly to some of the prominent features of this system.

Before doing so, however, it may be well for us to glance briefly at the systems already introduced in other cities—namely, Cleveland, Milwaukee, Detroit, Buffalo, Providence, Boston, and Chicago.

Plate I gives skeleton plans of the fire main systems of these cities (except Chicago, for which the writer was unable to obtain the data) in comparison with that of Philadelphia. All the figures are drawn to the same scale (1 inch = 3000 feet), and show merely the streams, etc., from which the supply is taken, the locations of the several fire mains, and (in numerals) the diameters of the mains, in inches.

As will be seen, the systems differ widely as to general arrangement; with Buffalo, and its single line, as one extreme, and Milwaukee, with its twenty-seven separate lines, as the other; while Philadelphia and Providence have each a loop or gridiron system.

Boston, where the system was laid in 1898, is the only city using salt water for fire extinction, although New York has for some time proposed the introduction of a system to be supplied with salt water, and Philadelphia may occasionally find herself using brackish water at high tide in seasons of extreme drought.

We may now consider each of these systems somewhat in detail.

Cleveland.

"In Cleveland the fire-boats had previously demonstrated their

usefulness to such an extent that in 1888 their limited radius of operation along the river banks was extended, under the auspices of the late James Dickinson, Chief Engineer of the Fire Department, by laying an ordinary 6-inch cast-iron pipe from the river to the top of the adjoining bank, a distance of 700 or 800 feet only, and without any idea of extending the system." *

The first permanent line was laid up Superior Street, from the river to Water Street, in December, 1891.

"About a month later, one of our largest business blocks, located at the corner of Superior and Seneca Streets, burned down. This

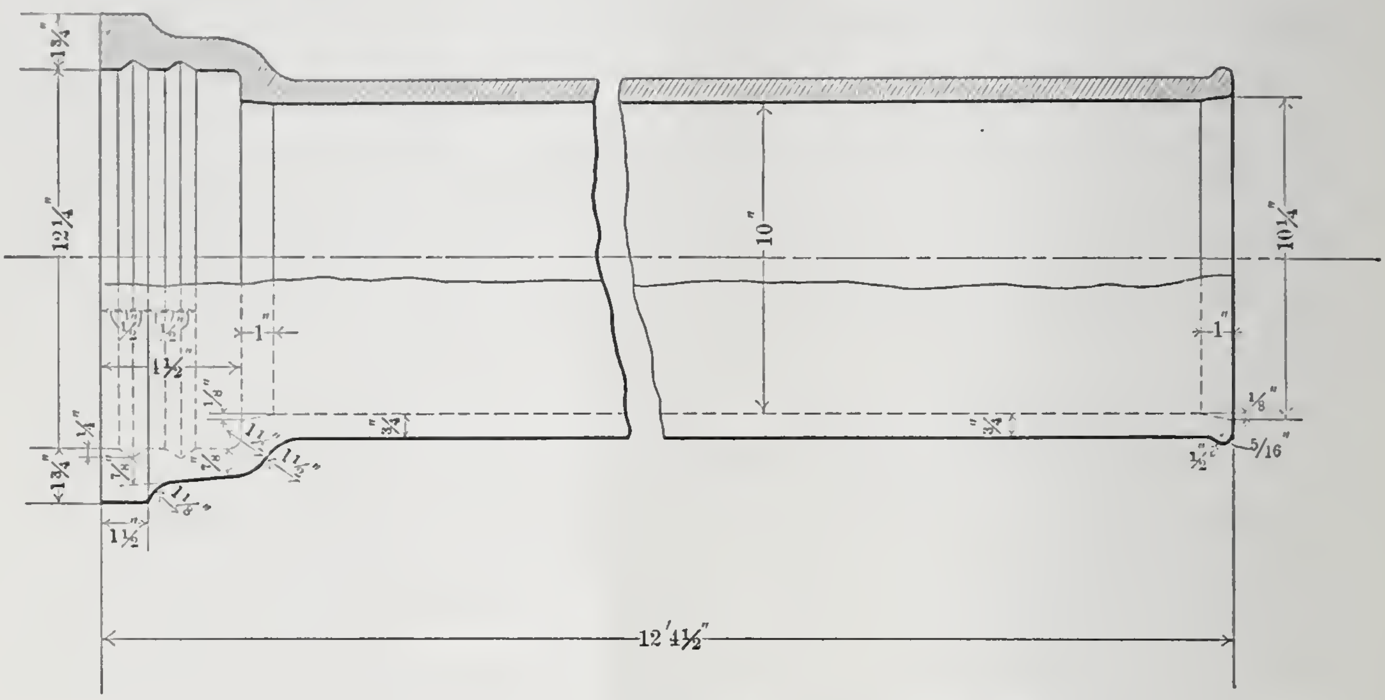

FIG. 1.—CLEVELAND, O. CAST-IRON PIPE FOR FIRE MAIN.

fire was nearly 1200 feet away from the hydrant at Water Street, and the line worked so successfully and they were able to use the boat to such advantage, although pumping through 1200 feet of hose, that they immediately made up their minds to equip other lines of pipes." †

The pipes are of cast iron, 10, 8, and 6 inches in diameter respectively, and with bell and spigot joints. The weights, per length laying 12 feet, are: 10-inch, 1011 pounds; 8-inch, 682 pounds; 6-inch, 475 pounds. They are laid only from 2 to 2½ feet below the surface, and are drained after each fire; but, in order to avoid danger of freezing, pipes laid in the future will probably be placed at greater depth.

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* See report by Foster Crowell to Merchants' Association of New York, 1900.

† Letter of Mr. Kingsley, late Superintendent of Waterworks, under date of June 25, 1898.

Cast iron was selected because it was found to be cheaper and less liable to corrosion than wrought iron, and easier to obtain with certainty as to regularity of delivery. Furthermore, it afforded better facilities for repairs and for taking off branches, and gave longer radii in bends.

The boats have several times carried pressures of 300 pounds per square inch, and up to July, 1898, not a joint had been broken.

The joints have double grooves for lead, in order to increase their strength. (See Fig. 1.)

The writer, having heard that the pressures in the Cleveland mains had been so greatly diminished by concretions that it had been found necessary to resort to the use of steam fire engines, addressed an inquiry to Mr. Kingsley on this subject. Mr. Kingsley replied as follows:

"CLEVELAND, O., *Oct.* 3, 1902.

"JOHN C. TRAUTWINE, JR.,

"257 S. Fourth St., Phila., Pa.

"*Dear Sir:* Your letter of October 1st received this morning and I hasten to reply in reference to the statement which was told you that 'the fire pipe lines of this city had suffered from interior incrustation, and that it had been necessary to use portable steam fire engines in order to get sufficient pressures on fire.'

"On receipt of your letter I immediately called up Chief Engineer Wallace, of the Fire Department, by telephone and read your letter to him. His reply was, 'Not a word of truth in that report.'

"The party making that report to you was entirely misinformed in regard to the matter. In fact, any person that is acquainted with the action of the water on cast-iron pipe, properly coated, in this city would have known better than to have made that assertion.

"Trusting that this will give you the desired information, I remain,

"Yours truly,

"M. W. KINGSLEY."

MILWAUKEE.

In Milwaukee the system consists of twenty-seven separate short lines extending into the city from arms of Lake Michigan. A plan of the system is shown in Plate I. The pipes are of cast iron, of 6-inch, 8-inch, and 10-inch diameters, with lead joints not less than 2½ inches deep, and of the thicknesses usually provided for in water-pipes of their respective diameters. They are laid at depths of 3

and 4 feet, and are filled in the spring, but in winter are drained; most of them to the river, a few into sewers.

The first line was laid in 1889; and here, as in Cleveland, the favorable results obtained led to a vigorous development of the system.

Before the introduction of the fire pipe lines, cisterns, sunk in the ground, were used for the supply of the steam fire engines. These are now placed only at points beyond the reach of the fire pipe lines.

Many of the lines are planned for future extension, and the system bids fair to become the chief dependence of the city.

The system comprises a total length of 41,419 feet, or nearly eight miles, upon which are placed 164 fire hydrants.

The system is served by three fire-boats, each of a capacity of 6000 gallons per minute.

The mains are of cast iron, that material being preferred chiefly on account of its superior durability. No special precaution is taken as to the joints, except to insure thoroughness of calking, and no trouble with the joints has been experienced while the mains have been under high pressure during service.

Detroit.

In Detroit, the system, completed in 1893, consists of seventeen completed lines, mostly on parallel streets running at right angles to Detroit River, and with a total length of 25,831 feet, rendering the fire-boat pressure available about half a mile from the river.

The supply is taken from the Detroit River by two fire-boats with a capacity of 5000 gallons per minute each, and a water pressure of 240 pounds per square inch.

The system consists chiefly of three long lines of 2000 feet each, and three short lines of 1000 feet each.

The mains, 8 and 10 inches in diameter, are of lap-welded steam-pipe, with screw couplings and tar coated; and similar to that used by the Standard Oil Company.

The lines slope toward the river for drainage, and are emptied after use. They were tested to 1000 pounds per square inch.

In connection with the steam fire engine service are 500 underground cisterns, with a total capacity of 4,000,000 gallons, 7000-gallon tanks being used at the dead-ends, and 20,000-gallon tanks in the central part of the city.

Mr. Tryon writes: "Since I told some gentlemen of our throwing a $1\frac{3}{4}$-inch stream horizontally 484 feet, and saw the look of polite

incredulity upon their faces, I have been very chary of speaking of results."

In Detroit, according to Mr. Tryon's paper, but two failures of the system had occurred up to that time (June, 1894) after the system had been in use about a year. One of these was due to the failure of the air valve to work, owing to the insufficient load, which made it impossible to fill the pipe; and the other was due to the failure of a relief valve to work, it having been set for too high a pressure. In the latter case the damage consisted in the blowing off of the Siamese.

The writer has recently learned that considerable trouble has been experienced in Detroit by reason of electrolytic action, as would appear from the following quotation from a letter recently received from Colonel W. H. Bixby, member of this Club, now residing in Detroit:

"About a mile total length of steel pipe line, belonging to the Fire Department, was injured in spots recently by electrolysis. None of this pipe has yet been taken up, because it is deep down below the surface and hard to get at, and the Fire Department has no funds available for the work. Such leaks as have been found appear to be only at pipe crossings—that is, probably in a few spots only, and not everywhere. If the pipe crossings were all well known, the trouble might be remedied with but little expense. Similar trouble occurred here in previous years with gas-pipes, where they crossed each other or crossed the trolley line circuits. In that case the railroad company stopped almost all further damage by tying all these pipes together so as to make one continuous circuit of them. The trolley company offered to do the same thing for the Fire Department, but the latter was unwilling, for various reasons."

Mr. Clarence W. Hubbell, Assistant to the Board of Water Commissioners, writes: "One block of pipe, 8-inch diameter, near my office, has just been renewed. The pipe was 22 feet deep in clay soil. The interior of pipe seems to be in fair condition, but badly pitted from outside surface. Seems to be due to soil as well as electrolysis. Voltmeter showed pipe negative to rail, with a difference in potential not to exceed two volts."

Buffalo.

Buffalo has a single line of over 6000 feet of 12-inch wrought-iron pipe, finished in 1897 and tested to a pressure of 1000 pounds per square inch.

The pipe is laid about 4 feet deep, and on such a grade as to drain it into the river; but it is kept full during the warm weather.

The specials are also provided with screw and lead joints and tested to 300 pounds per square inch. The boat connection consists of seven lines of 3½-inch hose.

There are two fire-boats, with a total capacity of 10,000 gallons per minute, and they can fill the pipe in three minutes and forty seconds.

The hydrants and fittings were furnished by the Murdoch Valve Company, of Detroit, and some of the hydrants also by R. D. Wood & Co.

Air valves, working both ways and set at 300 pounds and at 200 pounds, are placed on all summits, to allow the air to escape when the pipe is being filled. They act as relief valves when the main is under working pressure.

The pressure is 300 pounds per square inch at the boats, and 165 pounds at the upper end of the line.

A manhole, 7 feet by 3 feet, is placed around each valve, and each manhole is provided with a large cover, 4 feet in diameter, for entering the manhole, and with a small cover, 9 inches in diameter, placed directly over the valve stem. The valve stems are brought up to 1 inch below the bottom of the cover. The weight of cover and frame is about 1600 pounds.

It is proposed to extend the system so as to cover the business portion of the city.

The wrought-iron pipe in use gives entire satisfaction, and, with the screw and lead joints, gives a perfect line.

The cost of the line was about $22,000, or $3.50 per lineal foot.

It is proposed to lay a main along the water front.

Providence.*

In Providence, which was already well protected against fire, the system, which was installed in 1897, differs from all others now in use, in that the fire pipe line is supplied, and its maximum pressure maintained, by connection with a high-service reservoir of the city water-supply, which is drawn upon for the supply of the fire mains when the latter are in service.

This reservoir is 275 feet above city datum, and the supply for the

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* See paper by Mr. Edmund B. Weston, in "Journal of New England Water-works Association," vol. XIII, No. 2.

fire pipe lines is taken at a point three miles from the reservoir. A pumping plant is contemplated, and this will add 50 pounds per square inch to the pressure.

The pipe line is an irregular loop surrounding the greater part of the business portion of the city.

The area protected is a little more than half a square mile, or say 22,000 acres.

The supply is taken from a 24-inch supply and delivery main. The pipes are exceptionally large, being of 24-inch, 16-inch, and 12-inch diameter.

The static pressure on the hydrants ranges from 116 to 85 pounds per square inch, and in the center of the business portion of the city the pressure will not fall below 100 pounds per square inch under an average draft of 5,000,000 gallons for twenty-four hours, equal to 3472 gallons per minute.

The cost of the system was $139,749, or $4.75 per lineal foot.

The pipes are laid, in general, about 6.25 feet deep, or 1.6 feet deeper than the water-supply mains, in order that the fire pipe line might pass under the water-pipes and other obstructions, and also to prevent freezing.

The fire main system is connected with the low-service water-supply system by means of a by-pass, and also has three blow-offs. For more than four months, during the winter of 1897 and 1898, the by-pass was open "about two turns," "a few times," passing about 40,000 gallons per day, and "every morning, during the same period," two blow-offs were opened about fifteen minutes, giving 1100 gallons more. The minimum temperature of the water did not fall below 37°.

Boston.

Boston has a single fire pipe line, extending from the harbor at Central Wharf, through Central, Exchange, and Devonshire Streets, Post-office Square and Congress Street, to the harbor again at Congress Street bridge, a total length of 5000 feet, with a check valve at each end. The hydrants are placed 300 feet apart. Gates are placed in the line, dividing it into sections, which thus may be isolated from each other. A 6-inch relief valve is placed at each end of the line.

The main is of 12 inches diameter, and the metal is cast iron 1 inch in thickness.

Extra heavy double grooved bell and spigot joints are used.

The pipes were tested at the foundry to a pressure of 500 pounds per square inch and were dipped in distilled coal-tar.

The system is served by two boats, each of a capacity of 6000 gallons per minute.

The maximum pressure, at the fire-boat, is 200 pounds per square inch.

Each end of the pipe line has two fire-boat connections, so that each boat can connect at either end, or both boats at one end. Each connection has six 3½-inch outlets; and the hose lengths, between boat and connection, are between 15 and 30 feet long.

In order to insure the maintenance of pressure throughout the pipe between the two check valves, and up to the foot valves of the hydrants, and to prevent the accumulation of air, a 1-inch pipe leads from the main to a tank on top of the Post-office building. The tank is supplied from the city's fresh-water main, and check valves prevent the salt water from the fire main from backing up into the fresh-water tank.

The major portion of the pipe, being below tide level, is kept full of water at all times; and, the water being salt, there is no danger of freezing.

At each end of the pipe, beyond the check valves, a short exposed length of pipe is emptied in cold weather. These ends are provided with air cocks.

"An alignment free from sharp bends, either vertical or horizontal, was insisted upon and obtained with difficulty. At many points the way was absolutely blocked within 6 feet of the surface by water-pipes, gas-pipes, sewer connections, fire reservoirs, conduits of all kinds and shapes, etc., etc., and at times the excavation was in brick and concrete rather than in earth."

No leakage was observed in the main, or, at most, not enough to be indicated by a 1-inch meter on the pipe leading to the tank in the Post-office.

Should salt water prove injurious to the pipe, the pipe can be filled with fresh water after it has been used.

The telephone line consists of a five-conductor cable, two conductors forming the metallic circuit, while the other three are in reserve. This cable is carried in a 3-inch cement-lined wrought-iron duct, with concrete on the outside, laid in the main pipe branch, and forms part of the fire-alarm system of the city.

Branches are provided for extensions aggregating about two miles in length, with one or more additional water-side connections.

There are eleven Batchelder post hydrants, each with three 3-inch outlets, each outlet having its independent valve, and each hydrant is provided with a valve cutting it off from the line.

The valves, etc., are of composition metal, and pure rubber washers are used for insulation between wire and composition metal. The hydrants are emptied when not in use.

Following are records of two tests of the Boston fire main, made November 13, 1898, and May 7, 1899, respectively. In each case but one fire-boat was in service.

The volumes of water thrown are calculated, by Mr. John R. Freeman's formula, from the pressure at base of play-pipe and diameter of nozzle.

For these results the writer is indebted to Mr. F. A. McInnes, Assistant Engineer, City Engineering Department, Boston. The first table was published, with Mr. McInnes's paper, describing the Boston system, in the "Journal of the New England Waterworks Association," from which it is reprinted, by permission.

Chicago.

In Chicago about two miles of 12-inch pipe are being laid in the business district, and will be completed in about two months. There is already one short line of 8-inch pipe in the lumber district, and one in South Chicago.

New York (Proposed).

New York has thus far done nothing in the way of actual construction of fire pipe lines, although her great length of water front relatively to her area, and the enormous concentration of business in the lower part of the city, render the introduction of such a system peculiarly advantageous there; and Mr. Foster Crowell, in his report of 1900 to the Merchants' Association of New York, submitted elaborate plans for several alternative systems. The services include, besides fire protection, the washing and cooling of streets and the flushing of gutters and sewers.

Mr. Crowell recommended beginning with the dry-goods district, bounded by Chambers, Canal, and Hudson Streets, and Broadway, a district of 100 acres, the cost of which he estimated at $110,000, or $1000 per acre. His system comprised 14-inch, 12-inch, and 8-inch mains, with 8-inch stand-pipes and connections.

A second district, extending from Canal Street to Bleecker Street

and from Fifth Avenue to Broadway and containing 91½ acres, was estimated to cost $100,650, or $1100 per acre.

A third district, extending from Chambers Street to the Battery and from river to river, contains 273 acres. The estimated cost was $300,000, or $1100 per acre.

A fourth district extends from Division Street to Houston Street and from the Bowery to the East River. This system, provided with 12-inch and 8-inch pipes (constituting a system of the second order in Mr. Crowell's classification), was estimated to cost $276,700, with a pumping station costing $50,000, making a total of $326,700, or $1054 per acre.

The district south of Twenty-third Street, and extending from river to river, contains 2400 acres, and the cost was estimated at $2,400,000, or $1000 per acre.

These systems would be supplied with sea-water. Mr. Crowell recommended the installation of a roof service, with a fixed stand-pipe at a convenient street intersection, and connections with private stand-pipes.

There are six fire-boats, with an aggregate capacity of 39,300 gallons per minute, equivalent to that of 90 ordinary steam fire engines, as determined comparatively by tests in Boston.

The hulls of the fire-boats are built with suction chambers, that of the "New Yorker" having 2000 holes of ½-inch diameter.

Philadelphia.

We now come to the consideration of our own system.

During recent years the concentration of business in the district embraced between Delaware Avenue and Broad Street, and between Race and Walnut Streets, and the construction, in that district, of tall buildings, sometimes in alleged disregard of proper and legal precaution against fire, together with the admitted insufficiency and deterioration of the mains and the feeble pressures due to the notorious waste of water, had induced the underwriters to increase the rate by 25 cents per $100, pending the installation of the independent fire-pipe system; but, after the exhibition at Eighth and Market Streets, on the evening of May 2, 1902, a reduction of 15 cents was made, covering the district as far westward as Ninth Street; and, after the exhibition at Broad and Sansom Streets, on the afternoon of September 15, 1902, the reduction was extended to cover the rest of the district.

SALT-WATER FIRE PIPE TEST, BOSTON, MAY 7, 1899 (ONE FIRE-BOAT IN SERVICE)

DISCHARGE FROM NOZZLES

1	2	3	4	5	6	7	8
			LINE No. 1				
Experiment Began.	Experiment Ended.	Elapsed Time.	Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Pressure at Base of Play-pipe (Indicated).	Discharge per Minute.
H. M. S.	H. M. S.	M. S.	Ft.	In.	In.	Lbs.	Gal.
10-08-00	10-13-00	5-00	800	3	1½		
10-13-00	10-14-30	1-30	"	"	"	80	596
10-14-30	10-16-00	1-30	"	"	"	80	596
10-16-00	10-17-00	1-00	"	"	"	79	591
10-17-00	10-17-30	0-30	"	"	"	77¼	585
10-17-30	10-19-00	1-30	"	"	"	81½	599
10-44-00	10-48-30	4-30	50	3	2		
10-48-30	10-49-30	1-00	"	"	"	56¾	971
10-49-30	10-51-00	1-30	"	"	"	59¾	997
10-51-00	10-53-30	2-30	"	"	"	61	1006
11-27-00	11-37-30						
11-35-30	11-37-30						
11-37-30	11-39-30						
11-39-30	11-41-00						

1	9	10	11	12	13	14	15	16	17	18
	LINE No. 2.					LINE No. 3.				
Experiment Began.	Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Pressure at Base of Play-pipe (Indicated).	Discharge per Minute.	Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Pressure at Base of Play-pipe (Indicated).	Discharge per Minute.
H. M. S.	Ft.	In.	In.	Lbs.	Gal.	Ft.	In.	In.	Lbs.	Gal.
10-08-00	800	3	1½			200	3	1½		
10-13-00	Siamesed with line 1 into Eastman set, having 16' of 3½" hose.					"	"	"	81	606
10-14-30						"	"	"	80	604
10-16-00						"	"	"	78¾	596
10-17-00						"	"	"	80½	605
10-17-30						"	"	"	82½	611
	50	3								
10-44-00	16	3½	2			50	3	2		
10-48-30	"	"	"	56	918	"	"	"	57	974
10-49-30	"	"	"	57¼	928	"	"	"	59½	994
10-51-00	"	"	"	58¼	936	"	"	"	60	997
11-27-00										
11-35-30										
11-37-30										
11-39-30										

1	19	20	21	22	23	24	25	26	27	28	29	30
	LINES Nos. 4, 5, AND 6.						LINES Nos. 7, 8, AND 9.					
Experiment Began.	Length of Hose, Each Line.	Diam. of Hose.	Diam. of Nozzle on Each Line.	Pressure at Base of Play-pipe, Line 4 (Indicated).	Discharge per Minute, from Line 4.	Approx. Discharge from Hyd. Assuming Discharge from Lines 5 and 6 = Line 4	Length of Hose, Each Line	Diam. of Hose.	Diam. of Nozzle on Each Line.	Pressure at Base of Play-pipe, Line 7 (Indicated).	Discharge per Minute from Line 7.	Approx. Discharge from Hyd. Assuming Discharge from Lines 8 and 9 = Line 7.
H. M. S.	Ft.	In.	In.	Lbs.	Gal.	Gal.	Ft.	In.	In.	Lbs.	Gal.	Gal.
10-08-00												
10-13-00												
10-14-30												
10-16-00												
10-17-00												
10-17-30												
10-44-00												
10-48-30												
10-49-30												
10-51-00												
11-27-00												
11-35-30	100	3	1¼	80½	413	1239	100	3	1½	67½	553	1659
11-37-30	"	"	"	83½	421	1263	"	"	"	72	572	1716
11-39-30	"	"	"	80¾	414	1242	"	"	"	67½	552	1656

1	31	32	33	34	35	36	37	38	39	40	41	42	43	Remarks
	LINES Nos. 10, 11, AND 12													
Experiment Began.	Length of Hose, Each Line	Diam. of Hose.	Diam. of Nozzle on Each Line.	Pressure at Base of Play-pipe, Line 10 (Indicated).	Discharge per Minute from Line 10.	Approx. Discharge from Hyd. Assuming Discharge from Lines 11 and 12 = Line 10	Total Discharge per Minute.	Pressure at Hydrant, Corrected for Line 1.	Discharge per Min. of Line 1 or 2, Being ½ Discharge as Shown in Column 8.	Loss of Pressure in Line 1, 800' 3" Hose, with Discharge as Shown in Column 39 (Corrected).	Loss of Pressure, in 100' 3" Hose, with Discharge as Shown in Column 39.	Loss of Pressure in Line 3, 200' 3" Hose, with Discharge as Shown in Column 18 (Corrected).	Loss of Pressure in 100' 3" Hose, with Discharge as Shown in Column 18	
H. M. S.	Ft.	In.	In.	Lbs.	Gal.	Gal.	Gal.	Lbs.	Gal.	Lbs.	Lbs.	Lbs.	Lbs.	
10-08-00														At 10-08 A.M. pumps started.
10-13-00							1202	175¾	298	88¼	11	91⅓	47¼	
10-14-30							1200	174½	298	87	11	94	47	
10-16-00							1187	175¼	296	89	11	98	49	
10-17-00							1190	175½	293	90	11¼	91¼	47	
10-17-30							1210	179	300	90	11¼	96½	48¼	At 10-19 A.M. shut down. From 10-19 A.M. to 10-44 A.M., changing hose, etc.
										Loss of pressure in 50' of 3" hose, with discharge shown in col. 8.	Loss of pressure in 100' of 3" hose, with discharge shown in col. 8.			
10-44-00														At 10-44 A.M. pumps started.
10-48-30							2863	109		51¼	108½			
10-49-30							2919	112		54¼	108½			
10-51-00							2930	114		55¼	110½			At 10-53-30 A.M. shut down. From 10-53-30 A.M. to 11-27 A.M., changing hose, etc.
								Corrected for line 7.		Loss of pressure in 100' of 3" hose, with discharge shown in col 29.				
11-27-00														At 11-27 A.M. pumps started
11-35-30	100	3	1¼	88	132	1296	1191	97¾		33¼				
11-37-30	"	"	"	91¼	140	1320	1209	99½		30½				
11-39-30	"	"	"	89½	136	1308	1206	97½		33¼				At 11-41 A.M. test ended.

SALT-WATER FIRE PIPE TEST, AT POST-OFFICE SQUARE, BOSTON, MASS., NOVEMBER 13, 1898 (ONE BOAT IN SERVICE).

Experiment Began.	Experiment Ended.	Elapsed Time.	Line No. 1.					Line No. 2.					Line No. 3.				
			Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Indicated Pressure at Base of Play-pipe.	Discharge per Minute.	Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Indicated Pressure at Base of Play-pipe.	Discharge per Minute.	Length of Hose.	Diam. of Hose.	Diam. of Nozzle.	Indicated Pressure at Base of Play-pipe.	Discharge per Minute.
H. M. S.	H. M. S.	M. S.	Ft.	In.	In.	Lbs.	Gal.	Ft.	In.	In.	Lbs.	Gal.	Ft.	In.	In.	Lbs.	Gal.
10-27-30			150	3	1¾			150	3	1¾			150	3	1¾		
10-28-00	10-28-30	0-30	"	"	"	44.3	627	Into Eastman set.	"	"	45.3	617	Into Eastman set.	"	"	44.5	611
10-28-30	10-29-00	0-30	"	"	"	50.0	668		"	"	51.8	660		"	"	50.3	651
10-29-00	10-30-00	1-00	"	"	"	55.6	703		"	"	56.1	687		"	"	55.0	680
10-30-00	10-31-00	1-00	"	"	"	57.7	716		"	"	58.1	699		"	"	57.0	693
10-31-00	10-31-30	0-30															
10-31-30	10-32-00	0-30	150	3	1¾	49.5	664	150	3	1¾	51.3	657	150	3	1¾	50.0	648
10-32-00	10-32-30	0-30	"	"	"	54.0	693	"	"	"	55.3	682	"	"	"	54.5	677
10-32-30	10-33-30	1-00	"	"	"	57.0	712	"	"	"	58.3	700	"	"	"	57.0	693
10-33-30	10-40-00	6-30	"	"	"	58.8	724	"	"	"	59.0	708	"	"	"	57.5	696
10-40-00	10-41-30	1-30	"	"	"	60.0	732	"	"	"	61.8	721	"	"	"	58.1	699
10-41-30	11-11-30																
11-11-30			300	3	1¼			300	3	1¼			300	3	1¼		
11-12-00	11-13-00	1-00	"	"	"	75.6	400	"	"	"	70.7	387	"	"	"	65.0	371
11-13-00	11-14-00	1-00	"	"	"	86.8	429	"	"	"	82.0	417	"	"	"	85.2	425
11-14-00	11-15-00	1-00	"	"	"	93.5	445	"	"	"	88.8	434	"	"	"	93 9	446
11-15-00	11-17-00	2-00	"	"	"	100.0	459	"	"	"	94.8	448	"	"	"	101.3	463
11-17-00	11-18-30	1-30	"	"	"	102.2	465	"	"	"	97.8	455	"	"	"	104.8	471
11-18-30	11-19-30	1-00	"	"	"	104 4	470	"	"	"	105.2	472	"	"	"	109.1	481
11-19-30	11-21-00	1-30						"	"	"	111.0	485	"	"	"	120.9	506
11-21-00	11-35-30																
11-35-30			300	3		Siamesed with lines 2 and 3 into Eastman set.		300	3	2			300	3		Siamesed with lines 1 and 2 into Eastman set.	
11-36-00	11-36-30	0-30	"	"				"	"	"	81.5	1105	"	"			
11-36-30	11-38-00	1-30	"	"				"	"	"	89.3	1158	"	"			
11-38-00	11-39-00	1-00	"	"				"	"	"	91.0	1170	"	"			
11-39-00	11-41-30	2-30	"	"				"	"	"	94 6	1192	"	"			
11-41-30	11-49-00																
11-49-00			300	3		Siamesed with lines 2 and 3 into Eastman set.		300	3	2¼			300	3		Siamesed with lines 1 and 2 into Eastman set.	
11-49-00	11-50-00	1-00	"	"				"	"	"	46.5	1091	"	"			
11-50-00	11-50-30	0-30	"	"				"	"	"	55.7	1198	"	"			
11-50-30	11-51-00	0-30	"	"				"	"	"	60.6	1251	"	"			
11-51-00	11-52-00	1-00	"	"				"	"	"	63.5	1280	"	"			
11-52-00	11-54-00	2-00	"	"				"	"	"	66.0	1305	"	"			
11-54-00	11-55-30																
11-55-30			300	3		Siamesed with lines 2 and 3 into Eastman set.		300	3	2½			300	3		Siamesed with lines 1 and 2 into Eastman set.	
11-56-00	11-56-30	0-30	"	"				"	"	"	39.6	1317	"	"			
11-56-30	11-57-30	1-00	"	"				"	"	"	43.8	1383	"	"			
11-57-30	11-59-00	1-30	"	"				"	"	"	47.6	1442	"	"			
11-59-00	12-00-00	1-00	"	"				"	"	"	48.8	1462	"	"			

Experiment Began.	Line No. 4.					Line No. 5.				Line No. 6.				Total Discharge per Minute.	Pressure at Hydrant Outlets, Line No. 1.	Loss of Pressure in Hose, Line No. 1, Corrected.	Loss of Pressure per 100' under Given Discharge.	Remarks.
	Length of Hose.	Diam. of Hose.	Diam. of Base of Play-pipe.	Indicated Pressure at Nozzle.	Discharge per Minute.	Length of Hose.	Diam. of Hose.	Diam. of Base of Play-pipe.	Discharge per Minute (Approx.).	Length of Hose.	Diam. of Hose.	Diam. of Base of Play-pipe.	Discharge per Minute (Approx.).					
H. M. S.	Ft.	In.	In.	Lbs.	Gal.	Ft.	In.	In.	Gal.	Ft.	In.	In.	Gal.	Gal.	Lbs.	Lbs.	Lbs	
10-27-30																		Pumps started at 10-27-30.
10-28-00														1855	109.0	63.7	43	
10-28-30														1979	126.0	75.0	50	
10-29-00														2070	134.5	77.9	52	
10-30-00														2108	138.5	79.8	53	
10-31-00																		Shut down.
10-31-30														1969				
10-32-00														2052				
10-32-30														2105				
10-33-30														2128				
10-40-00														2152				Shut down at 10-41-30.
10-41-30																		Changing hose lines and nozzles.
11-11-30	300	3	1¼			300	3	1¼		300	3	1¼						Pumps started at 11-11-30.
11-12-00	"	"	"	72.6	392	"	"		388	"	"		388	2326	128.0	51.5	17.2	
11-13-00	"	"	"	84.4	423	"	"		424	"	"		424	2542	140.0	52 2	17.4	
11-14-00	"	"	"	93.0	444	"	"		412	"	"		442	2653	147.7	53.2	17.7	
11-15-00	"	"	"	98.7	457	"	"		457	"	"		457	2741	152.8	52.8	17.6	
11-17-00	"	"	"	101.3	463	"	"		464	"	"		464	2782	157.0	53.8	17.9	
11-18-30																		
11-19-30																		Shut down at 11 21-00
11-21-00															Pr. at hyd. outlets, P. O. Square.	Loss in lines, P. O. Sq. Hyd. corrected.		Changing nozzles
11-35-30	300	3	2			300	3	Siamesed with lines 4 and 6 into Eastman set.		300	3	Siamesed with lines 4 and 5 into Eastman set.						Pumps started at 11-35-30.
11-36-00	"	"	"	76.3	1070	"	"			"	"			2175	131.5	52.0		
11-36-30	"	"	"	85.8	1135	"	"			"	"			2293	148.3	58.0		
11-38-00	"	"	"	88.5	1153	"	"			"	"			2323	151.5	59.5		
11-39-00	"	"	"	91.5	1173	"	"			"	"			2365	156.9	61.3		Shut down at 11-41-30.
11-41-30																		Changing nozzles.
11-49-00	300	3	2¼			300	3	Siamesed with lines 1 and 6 into Eastman set.		300	3	Siamesed with lines 4 and 5 into Eastman set.						Pumps started at 11-49
11-49-00	"	"	"	56.2	1205	"	"			"	"			2296				
11-50-00	"	"	"	60.2	1247	"	"			"	"			2445	128.5	71.8		
11-50-30	"	"	"	65.2	1298	"	"			"	"			2549	136.7	75.1		
11-51-00	"	"	"	66.7	1313	"	"			"	"			2593	143.0	78.5		
11-52-00	"	"	"	68.6	1331	"	"			"	"			2636	148.2	81.2		Shut down at 11-51-00
11-54-00																		Changing nozzles.
11-55-30	300	3	2½			300	3	Siamesed with lines 4 and 6 into Eastman set.		300	3	Siamesed with lines 4 and 5 into Eastman set.						Pumps started at 11-55-30.
11-56-00	"	"	"			"	"			"	"				110.5	78.9		
11-56-30	"	"	"	47.4	1439	"	"			"	"			2822	128.0	83.2		
11-57-30	"	"	"	50.0	1480	"	"			"	"			2922	140.7	92.1		
11-59-00	"	"	"	51.0	1493	"	"			"	"			2955	146.0	96.2		Shut down at 12-00.

Lines 1, 2, 3, from hydrant at Post-office Square.
Lines 4, 5, 6, from hydrant on Congress Street, near Milk Street.
In the last three sets of experiments, two Eastman sets were used with three lines from each hydrant.

Each Eastman set includes 16 feet of 3½-inch hose.

In the set of experiments with six 1¼-inch nozzles, the discharge from lines 5 and 6 is approximate, as no pressures were taken at the nozzles, therefore the total discharge for this set of experiments is approximate.

The remaining 10 cents per $100 remains until after the construction of the proposed pumping station.

During the years 1895 to 1899 there were, on Market Street east of Broad Street, one 20-inch main, laid in 1882, and two 6-inch mains, laid mostly in 1822 and 1823; and some of the latter, when taken up, were found incrusted to a depth of about half an inch with nodules, which very seriously crippled their carrying capacity. On Arch Street, between Second Street and Twenty-second Street, there was one 30-inch main, laid in 1850, and one 6-inch main; on Chestnut Street, east of Broad Street, two 10-inch mains, laid mostly between 1820 and 1840; on Walnut Street, from Front Street to Twenty-second Street, one 12-inch main; on Broad Street, a 6-inch main, of 1823, and a 20-inch and a 30-inch main, both of modern date.

In October, 1895, the writer, as Chief of the Bureau of Water, received from Mr. Thomas M. Thompson, then Director of the Department of Public Works, a communication transmitting a letter from Mr. Frank M. Riter, Director of the Department of Public Safety, and asking for an estimate of the cost of a 10-inch line on Market Street, extending from the wharf to Broad Street, to be supplied by fire-boats lying in the Delaware River.

Replying to this inquiry, the writer recommended, in accordance with the suggestion of Mr. A. J. Fuller, then Assistant in Charge of Distribution, that the pipe be made of 12 inches nominal ($11\frac{1}{8}$ inches actual) internal diameter, inasmuch as a so-called 10-inch pipe, of the thickness requisite to withstand the extraordinary pressure proposed, would have an actual internal diameter of only about $9\frac{1}{4}$ inches.

The estimate of cost, for the 12-inch line, was $17,204.50, including 510 lengths of 12-inch pipe, and 30 hydrants, so constructed as to open just below the level of the street or sidewalk, thus causing no obstruction to travel and offering less resistance to flow than do hydrants of the usual form.

It was found that the use of 10-inch (actually $9\frac{1}{4}$-inch) pipe, of sufficient thickness for the required pressure, would reduce this estimate about $2000, and the writer called the attention of the Director to the advisability of erecting a stationary pumping engine at or near the foot of Market Street, for the purpose of supplying this pipe, instead of relying upon the fire-boat.

In June, 1899, at the instance of the Philadelphia Fire Underwriters' Association, Mr. Charles G. Darrach, C.E., submitted a design for a system comprising lines of 12-inch wrought-iron pipe,

with screw joints, on Arch, Market, Chestnut, Fifth, Eighth, Twelfth, Broad, and Fifteenth Streets, supplied by a pumping station at Arch Street wharf, with fire hydrants at each street corner and midway of the block, on 8-inch branches, with independent valves and with a telephone at each hydrant.

Mr. Darrach submitted, at the same time, an estimate on a similar system with cast-iron pipes, 1 inch thick, with lead joints.

In each case the cost, including hydrants, telephones, etc., was estimated at $6 per lineal foot.

The proposed pumping station was to contain 3 Worthington compound, duplex, condensing pumping engines, each of a capacity of 3000 gallons per minute (4,320,000 gallons per day), against a pressure of 300 pounds per square inch. Two of these engines were expected to meet all requirements of service, while one was always to be held in reserve. There were to be six Babcock and Wilcox or Heine water-tube boilers, each of 200 horse-power. The estimated cost was: Lines complete, $176,130; pumping station, $95,500; total, $271,630, exclusive of real estate. The area protected being about 292 acres, this makes the cost, exclusive of pumping station, $603 per acre.

With two boilers under fire with hard coal and circulating the water in all the other boilers, and with water kept hot and the furnaces ready for instant commission, charged with wood and soft coal, Mr. Darrach estimated the cost of operation at $13,600 per annum.

The pressures to be maintained were: At Delaware River, 300 pounds per square inch; at Eighth Street, 240 pounds; and at Fifteenth Street, 200 pounds; and the maximum delivery, at remote points, was to be 6000 gallons per minute.

The present system was designed by the Bureau of Water, Mr. John Wallace Weaver being the engineer in charge of this special work. Mr. Weaver's force consisted of two draftsmen and one inspector, and the expenses of his office, from March 1, 1901, to January 1, 1902, were $3043.38, of which salaries amounted to $2533.60, surely not a lavishly extravagant expenditure, under the circumstances.

Plate II shows a plan of the system as at present completed, with its four main lines on Race, Arch, Market, and Walnut Streets respectively, that on Market Street being of 16-inch * pipe, while those on the other three streets are each of 12-inch * pipe. Owing to the exhaustion of the amount appropriated, the Race Street line extends

* See foot-note, p. 57.

westward only to Eleventh Street, while those on the other three streets extend practically to Broad Street.

These main east-and-west lines are connected by 8-inch * lines on Delaware Avenue and on Second, Fifth, Eighth, and Eleventh Streets, and by a 12-inch line on Broad Street, and provision is made, at the intersection of each remaining north-and-south street, for an 8-inch connection in such streets; while the Race and Walnut Street lines have connections for extensions beyond the limits of the district shown in the plan. The north-and-south lines at the western end of the present system are also provided with connections for extensions beyond the present limits.

The City Hall is surrounded by a line of 12-inch pipe; and just west of the City Hall the system is connected with the 12-inch main by which the City Hall alone is supplied with water from the Belmont reservoir.

This reservoir, standing at an elevation of 212 feet above city datum, maintains a constant pressure of 70 to 80 pounds per square inch upon the fire pipe line when the latter is not in active service for fire. When the fire pressure is brought upon the fire pipe line, it closes a check valve in the connection with the 12-inch main from Belmont, shutting off the Belmont reservoir pressure from the line.

The plan shows the location of fire hydrants and valves, and, by means of dots placed within circles, the locations of the telephone signal boxes.

Care has been taken to show, upon the plan, the location of The Engineers' Club of Philadelphia.

Three attachments for the fire-boats are provided, namely: one each at Race Street, Arch Street, and Walnut Street.

The total length of the pipe line is nearly eight miles; and the cost of the line complete, and that of the proposed pumping station, may each be stated, in round numbers, at about $300,000. The system comprises about 6,000,000 pounds of straight pipe and about 850,000 pounds of curved pipe.

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* The outside diameters are, as here given, 16, 12, and 8 inches respectively. The corresponding internal diameters are 7¼, 10$\frac{13}{16}$, and 14⅜ inches. It was originally intended to use 16-, 12-, and 8-inch steel pipe, and steel fittings for such pipe were secured. The cast-iron pipes, subsequently adopted, were necessarily made from ¾ to 1⅜ inches less in diameter than the steel pipes would have been, in order to correspond with these fittings. The thicknesses of iron in the three sizes of pipe are 1½, 1¼, and ⅞ inch, respectively.

After careful study of the systems in use in other cities, with special reference to the method of forming the pipe joints, it was decided to use flanged joints, in view of the heavy pressures and large diameters used here.

The pipes are cast in lengths of 12 feet. The flanges measure as follows:

	Flange.		Bolts.	
External Diameter of Pipe (Inches).	External Diameter (Inches).	Thickness (Inches).	Number.	Diameter (Inches).
16	22¼	2⅞	16	1⅛
12	17¾	2¼	12	1⅛
8	13¼	1¾	8	1

The packing, between the abutting flanges of two contiguous lengths of pipe, consists of 7-ounce army duck, free from wrinkles; and with North Carolina tar spread upon each side of the duck and upon each abutting flange. No trouble is experienced in getting the joints water-tight under a pressure of 400 pounds per square inch.

The straight and curved pipes were made by R. D. Wood & Company, their Camden foundry making 12-inch and 16-inch pipes, while that at Florence, N. J., made 8-inch and 12-inch pipes; the semi-steel crosses and T's were made by the Seaboard Steel Casting Company, Chester, Pa.; the valves by the Williamsport Valve Company. and the cast-iron stop-boxes by the Middletown (Pa.) Car Works.

All bends are of either 90° or 45°. The radii used for bends were as follows: For 8-inch pipe, 8 feet radius; for 12-inch pipe, 12 feet radius; and for 16-inch pipe, 16 feet radius.

The pipe was cast on end, and the flange at the upper end of each length was strengthened by as many brackets as there were inches in the diameter of the pipe, these brackets being intended to compensate for any weakness of the metal due to the lesser pressure existing at the top of the pipe, and to prevent cracking owing to unequal shrinkage in cooling.

All the material was inspected by Robert W. Hunt & Company, at the foundry. The pipes were tested under a pressure of 800 pounds per square inch, and the iron up to a tensile stress of 20,000 pounds per square inch.

In his report, under date of January 1, 1902, Mr. Weaver states: "From the cost of pipe already laid, we compute the maximum cost at $6.40 per foot for the 12-inch line complete, and $3.15 per foot

for the 8-inch line complete." These figures are exclusive of the cost of fire hydrants, which cost about $110 each.

As might have been expected, the work of laying the mains encountered innumerable difficulties in the way of previously existing subterranean structures of all descriptions. And, our predecessors having been less scrupulous than ourselves in the matter of recording the positions of such structures, many new discoveries of ancient facts were made during the work. These were in all cases carefully recorded, and not the least of the incidental benefits arising from the work is that of an important contribution to the knowledge of the Board of Highway Supervisors respecting the locations of such structures.

Up to January 1, 1902, over 2000 services had been encountered, and up to that time the total cost for broken services had not exceeded $100.

On Arch, Market, and Walnut Streets the locations of the new fire mains coincided with those of the old wooden water-pipes of bored logs, laid about 1801. The bottoms of these wooden pipes averaged about 6 feet in depth below the present surface. They were in 12-foot lengths, with 6-inch bore, of red oak, white oak, and yellow pine, and were found in a fine state of preservation after their century of service and rest.

Mr. Weaver's report recommends the erection of stand-pipes in large department stores, hotels, office buildings, etc., as an adjunct to the fire pipe line system, with nozzles at the roof and with hose connections at each floor, such stand-pipes to be independent of any existing private fire service. Similar stand-pipes are also recommended for erection at street corners.

Work was begun, at Delaware Avenue and Arch Street, on May 20, 1901, and the first public exhibition of the working of the system, then completed as far as Eighth Street, was made at Eighth and Market Streets on the evening of May 2, 1902. A far more exhaustive exhibition of the working of the entire system was made at Broad and Sansom Streets on the afternoon of September 15, 1902. Some account of each of these performances will be found below.

When the work was nearing completion, the local newspapers made merry, at the expense of the engineers in charge, over the fact that expansion joints were at that late day being introduced into the line, and the engineers were thought very remiss in not having anticipated the necessity for these devices in long lines of cast-iron pipe rigidly bolted together by their flanges.

The Bureau, however, believed, and it still believes, that no special precaution was necessary on account of expansion and contraction, holding that so much additional temperature stress as was not relieved by the numerous curves in the pipe would be easily taken care of by slight increases of stress in the metal itself, especially as, owing to the large body of water in the pipes, and the depth (6 feet) at which the pipes are laid, the extreme range of temperature between winter and summer was hardly likely to exceed about 30°.

It was found, however, that certain breaks had occurred, and always near the summit of a grade and immediately under the flange

FIG. 2.—PHILADELPHIA. SIAMESE, WITH AIR CHAMBER AND CONNECTING HOSE, AS SEEN FROM FIRE-BOAT.

of a pipe; and it was believed by those in charge that these fractures were due to the drag of the long length of pipe upon the grade.

The expansion joint consists of a sleeve surrounding the pipe, the annular space between pipe and sleeve being filled with sixteen strands of $\frac{1}{8}$-inch wire lead driven cold. Each strand, being 1 inch longer than the circumference of the pipe and plaited by hand, was put in the bell and driven home against a packing of hemp dipped in

North Carolina tar. This process was repeated until a point was reached 1 inch from the outer edge of the bell; the last inch was then filled with molten lead.

Tests of a number of these joints, under a pressure of 400 pounds per square inch, failed to show any percolation of moisture.

Each of these joints was surrounded by a manhole large enough to permit of recalking when necessary.

Similar provision was required also where the 8-inch lines, on the north-and-south streets, joined the larger mains laid on the east-and-

FIG. 3.—PHILADELPHIA. SIAMESE, WITH AIR CHAMBER REMOVED.

west streets, it being impossible to secure mathematical accuracy of fit as to the length of the 8-inch pipes.

The mains are laid 6 feet deep, and, it being believed that this would afford sufficient protection against freezing, no special provision has been made in this respect.

Figures 2 and 3 show photographic views of the boat connections, while figure 4 is a sectional view of the Siamese into which the eight lines of hose from the boat are led and from which the water is conveyed, under pressure, to the system.

In placing the fire-boat connections it was found necessary to cut through the concrete bulkhead recently built along the wharf by the Bureau of Surveys, under Chief Engineer Webster, and the labor entailed in doing this work bore testimony to the quality of the material placed in the wall.

All branch connections and all gate valves and fire hydrants are of semi-cast steel, a material made, as the writer understands, by the addition of steel scrap to the melted cast iron in the cupola.

The hydrants, 166 in number, are of $7\frac{1}{4}$-inch internal diameter, with two 4-inch outlets, each having an independent valve, and each

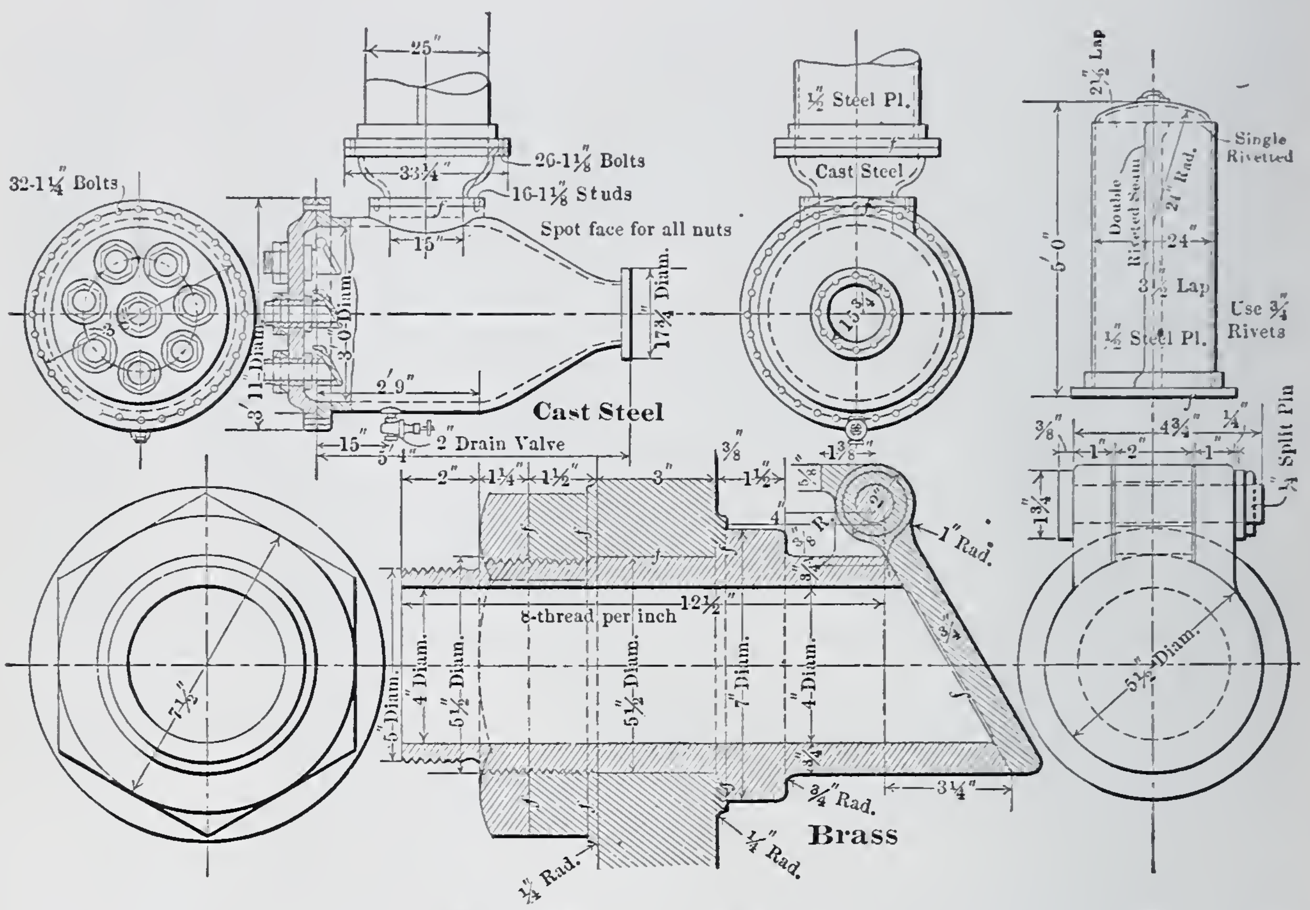

FIG. 4.—PHILADELPHIA. SIAMESE AND AIR CHAMBER, WITH DETAIL OF ONE OF THE EIGHT CHECK VALVES.

hydrant being controlled by a gate placed upon its connection with the main. (See Fig. 5.)

Each hydrant is automatically drained to the nearest sewer through a 1-inch galvanized iron pipe. Each hydrant weighs about 1000 pounds.

There are 261 gate valves upon the several lines, and the system has 87 1-inch air valves, for permitting the escape of air at summits.

The fire-boat "Stuart" has four Clapp & Jones pumps, each of a capacity of 2240 gallons per minute at 300 revolutions per minute.

The four police boats, which come under the charge of Fire Chief Baxter when an alarm sounds, are:

"Ashbridge," one Clapp & Jones pump, 1300 gallons per minute;
"Visitor," one Clapp & Jones pump, 800 gallons per minute;
"Stokley," one Worthington pump, 750 gallons per minute;
"King," one Silsby rotary pump, 1200 gallons per minute.

The Worthington pump on the "Stokley" is to be replaced by a Clapp & Jones pump of 1300 gallons per minute capacity.

The "King" is stationed on the Schuylkill River, the other four boats on the Delaware River.

The hose, nozzles, and other apparatus, intended for use in con-

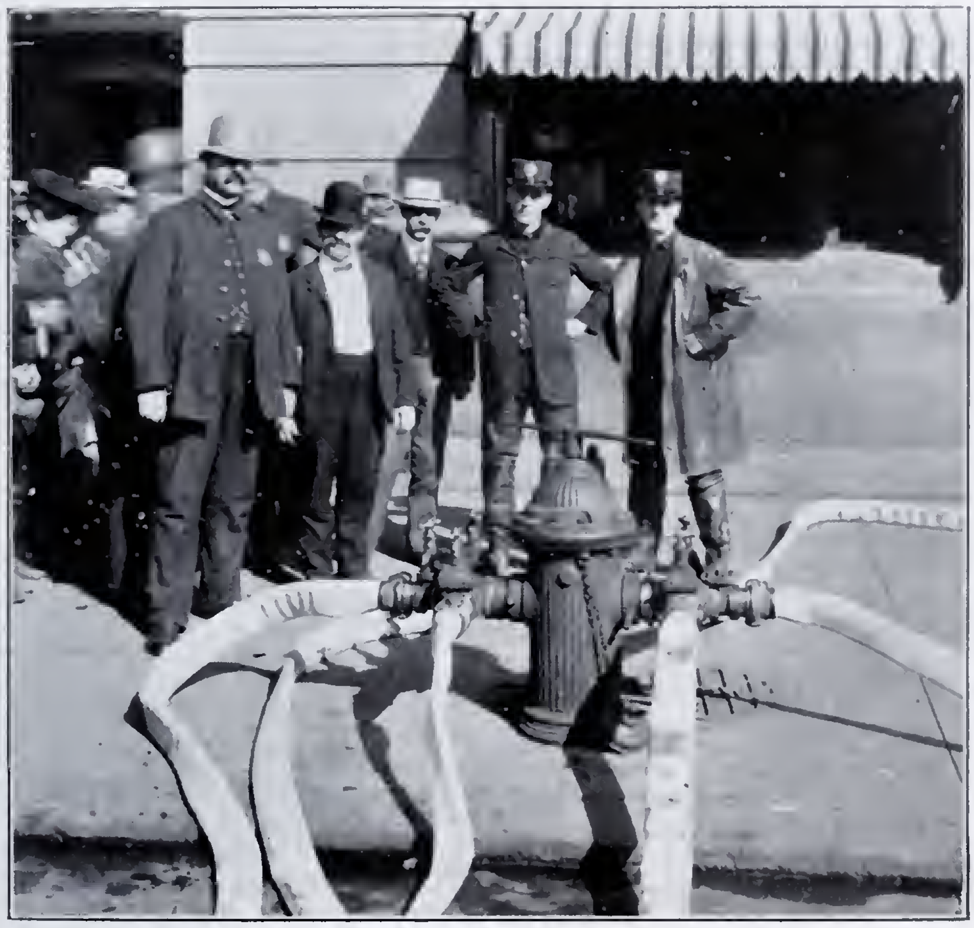

FIG. 5.—PHILADELPHIA. HYDRANT ON FIRE MAIN.

nection with the system, are stored in the house at the southwest corner of Sixth and Sansom Streets, formerly occupied by the chemical engines, which were removed to West Philadelphia upon the completion of the fire pipe line system.

All the telephonic communication in connection with the system is made by means of underground wires.

The system is designed to deliver twenty streams of 500 gallons per minute, or a total of 10,000 gallons per minute, or 14,400,000 gallons per day, with a pressure of 520 feet (225 pounds) at the pumps, and 440 feet (191 pounds) at the point farthest from the pumps.

The proposed pumping station is designed for a daily capacity of 15,000,000 gallons.

In the proposed new pumping station, the pumps are to be made by the Deane Steam Pump Co., of Holyoke, Mass. There will be seven vertical triplex double-acting power pumps, 11½ inches in diameter, and 12-inch stroke, each to deliver 1200 gallons per minute against a water-pressure of 300 pounds per square inch, at 40 revolutions per minute; and two similar pumps 6¼ inches in diameter, 12-inch stroke, each to deliver 350 gallons per minute against a water-pressure of 300 pounds per square inch, at 38 revolutions per minute.

These pumps will be driven by gas engines, that form of power development having been adopted for the obvious purpose of avoiding the necessity of keeping up fires under boilers during the entire year, whereas the system may not be called into service on half a dozen occasions during that time.

While the proposed combination of power pumps and gas engines is more expensive in first cost than a steam pumping plant for the same service, it is more economical in space (requiring no boilers or coal storage) and in cost of operation (no firemen being needed and no gas being burned while the system is not in service). Mr. Weaver estimates the annual cost of operating such a plant with steam at $15,300 and with gas at $11,700, showing a saving, for gas over steam, of $3600 per annum. This estimate is based upon a plant of 16,000,000 gallons daily capacity, with an average of one fire, of ten hours' duration, per month.

The first public exhibition of the working of the Philadelphia fire main system was made early in the evening of May 2, 1902, at Eighth and Market Streets, the mains having then been laid as far west as Eighth Street. For this exhibition the two hydrants at the northwest and southwest corners of Eighth and Market Streets were utilized. At first a single stream, through 50 feet of 3½-inch hose and a 2-inch nozzle, was thrown, under the pressure of Belmont reservoir alone. Next, with the three boats, "Stuart," "Ashbridge," and "Visitor," pumping, four streams (two from each hydrant) were thrown, each passing through 50 feet of 3½-inch hose and a 2-inch nozzle. Finally, with the boats still pumping, three lines of 50 feet of 2½-inch hose, with 1¼-inch nozzles, were led off from the end of each of the four 50-foot lines of 3½-inch hose, making twelve streams in all.

No accurate observations were made in connection with this exhibit,

so far as the writer is aware; but, as nearly as could be judged by observing the jets from the ground, and comparing their height with that of neighboring buildings, the extreme height seems to have reached about 140 or 150 feet.

A much more comprehensive exhibition of the new system as it stands to-day was given on the afternoon of Monday, September 15,

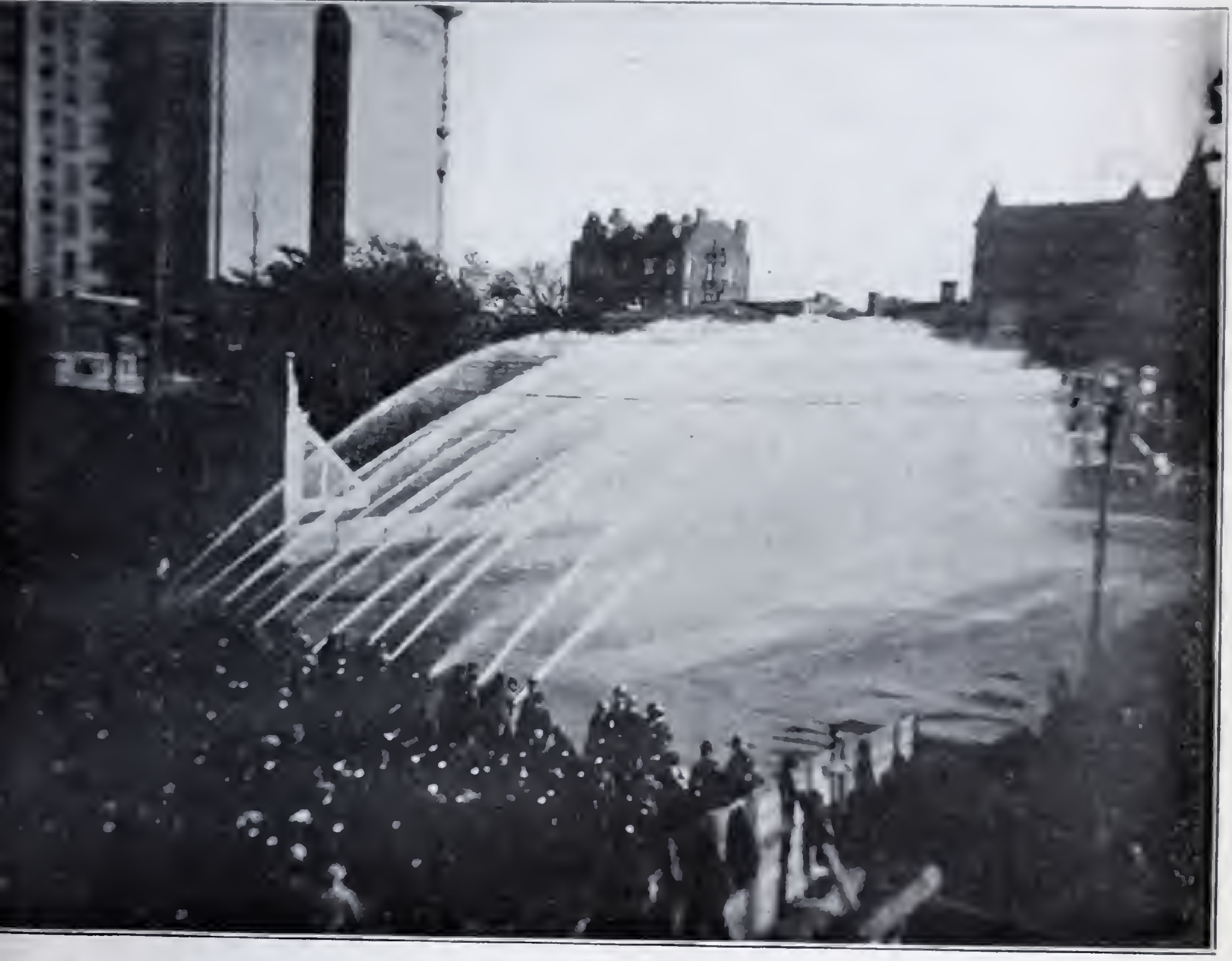

FIG. 6.—PHILADELPHIA, SEPTEMBER 15, 1902, 3.30 P. M. TWELVE STREAMS THROUGH TWELVE 300-FT. LENGTHS OF $2\frac{1}{2}$-INCH HOSE, WITH $1\frac{1}{4}$-INCH NOZZLES. PRESSURE FROM "STUART" AND "ASHBRIDGE." HYDRANT AT SIXTH AND RACE STREETS OPEN.

1902, at Broad and Sansom Streets. For this exhibition the hydrant on the northeast corner of Broad and Sansom Streets was used. Pressures were taken on an "idle" hydrant at the southwest corner of the same streets.

The exhibition was made principally under the direction of a Committee of the Philadelphia Fire Underwriters' Association, to whom

the writer is indebted for most of the following data respecting it, and for the use of the cuts illustrating it, figures 6 to 11.

The objects of the exhibition, as arranged by the Committee, were to show:

1. The number of effective streams which could be delivered through leads of 300 feet of $2\frac{1}{2}$-inch hose with $1\frac{1}{4}$-inch nozzles from the static

Fig. 7.—Philadelphia, September 15, 1902, 3.35 p. m. Twelve Streams through Twelve 300-ft. Lengths of $2\frac{1}{2}$-inch Hose, with $1\frac{1}{4}$-inch Nozzles. Pressure from "Stuart," "Ashbridge," and "Visitor."

pressure which is to be constantly maintained on the system from the Belmont reservoir without the aid of any fire-boat or pump pressure.

2. The number of effective streams which could be obtained under the same conditions, but with the aid of the pressure obtained from the fire-boats.

3. The effect of substituting 300 feet of $3\frac{1}{2}$-inch hose with 2-inch

nozzles instead of $2\frac{1}{2}$-inch hose with $1\frac{1}{4}$-inch nozzles, under gravity pressure from the reservoir, and also—

4. The same as the *third,* but under the fire-boat pressure.

FIG. 8.—PHILADELPHIA, SEPTEMBER 15, 1902, 4.09 P. M. ONE STREAM THROUGH 300 FEET OF $3\frac{1}{2}$-INCH HOSE, WITH 2-INCH NOZZLE. PRESSURE FROM "STUART."

5. The results to be obtained by connecting the fire-boat pressure with a water tower.

As will be seen in the plan, Plate II, the site selected for this exhibition was the most remote from the fire-boats, being about 1.2

miles from the Delaware River at Walnut Street, and about 1.3 miles, in a straight line, from the Delaware at Race Street. It is also about the highest point in the system, being at an elevation of about 43 feet above city datum, which latter, in the absence of definite information, may be taken as about the mean height of the gauges on the boats.

Fig. 9.—Philadelphia, September 15, 1902, 4.12 p. m. Four Streams through Four 300-ft. Lengths of $3\frac{1}{2}$-inch Hose, with 2-inch Nozzles. Pressure from "Stuart."

The "Stuart" was in action at the foot of Race Street, and the "Ashbridge" and the "Visitor" at the foot of Walnut Street; the "Stuart" pumping through eight lines of $3\frac{1}{2}$-inch hose, the "Ashbridge" through four lines of $2\frac{1}{2}$-inch hose, and the "Visitor" through three lines of $2\frac{1}{2}$-inch hose, each line of hose, from boat to Siamese, being 50 feet long.

All the gates in the system were thrown open, so that the entire

system was under pressure and available for the flow of the water, and a hydrant at Sixth and Race Streets was opened occasionally, in order to determine the effect of such opening if it should at any time be required. This hydrant was provided with 50 feet of 3½-inch hose and a 2-inch nozzle. Its elevation was about 28 feet above city datum.

FIG. 10.—PHILADELPHIA, SEPTEMBER 15, 1902, 4.51 P. M. WATER TOWER. PRESSURE FROM "STUART."

At the conclusion of the experiments tabulated below, and at the suggestion of the Chief of the Bureau of Fire, an exhibition was given of the comparative power of a steam fire engine and the high-pressure system under pressure from the "Stuart" pumps. The fire engine, a remodeled Campbell & Rickards (piston type) of about 500 gallons capacity, drew water from an old city hydrant on Broad Street (6-inch

main), and discharged through 300 feet of $2\frac{1}{2}$-inch hose, with $1\frac{1}{4}$-inch nozzle, while the high-pressure stream was delivered through 50 feet of $3\frac{1}{2}$-inch hose, with 2-inch nozzle (see Fig. 11). The comparison

Fig. 11.—Philadelphia, September 15, 1902. One Vertical Stream through 50 Feet of $3\frac{1}{2}$-inch Hose, with 2-inch Nozzle.

showed, horizontal streams: fire engine, 175 feet; high-pressure system, 315 feet; vertical streams: fire engine, about 125 feet; high-pressure

system, about 230 feet (effective fire stream probably 200 feet), under water pressures at boat varying from 200 to 250 pounds, and at fire engine from 100 to 140 pounds.

During the exhibition of September 15th, soft coal was used on the fire-boats and on the fire engine, which was to the disadvantage of both. The gauges used were furnished by the city, and were mercury column gauges at the idle hydrants, and H. Belfield & Co. commercial gauge at coupled hydrant and at play-pipe.

The fire-boat pressure was felt one and a half minutes after requesting the Chief of the Fire Bureau that it be turned on, and the full pressure was reached in about five minutes.

It was found that six men unaided could handle the 2-inch nozzle, and four men could handle it if provided with sticks which served as supports for the nozzle, while three men could manage the 1½-inch nozzle without and two men with sticks.

The following tables give a chronological record of the experiment. A number of discrepancies are observable in the figures given. Some of the more prominent of these are indicated by interrogation points. Unfortunately, only one dial gauge was provided; hence, where pressures at the active hydrant at Broad Street are given, those at the base of the play-pipe are wanting, and *vice versâ*. After using this gauge on the active hydrant, in the first set of experiments (A), it was found out of order. After repair, it was used on the play-pipe in the second set of experiments (B), but its indications there are believed to be much too low. The differences in the pressures shown at the boats, under uniform conditions, are no doubt due to differences in the resistances, between boat and Siamese, against which they pumped.

Some of the variations noted in hydrant pressures are no doubt due to the necessity of shutting down one or more of the streams, from time to time, for the purpose of removing, from the nozzles, stones, pieces of rope, etc., carelessly left in the mains during construction.

In figure 12 the writer has attempted a crude graphic representation of the results marked A, B, C, D, E, F, and G, in the foregoing tables, using a double line for experiment A (3½-inch hose, with 2-inch nozzle) and single lines for the remaining experiments (2½-inch hose, with 1¼-inch nozzle), experiment C, where the Race Street hydrant was open, being indicated by a broken line.

(A) EXPERIMENTS WITH LINES OF 300 FEET OF 2½-INCH HOSE AND 1¼-INCH NOZZLES.

Time (P. M.).	Number of Streams.	Pressure Taken from	Pressure (Pounds per Square Inch). At Boat.* S.	A.	V.	At Race St.	At Broad St.† Idle.	Active.	Horizontal Throw (Feet).	Remarks.
2.55	0	Belmont.				81	71			Static pressure.
	1	"				75	65	50	65	E, Fig. 12.
	2	"				75	65	50	50	
	3	"				52	50	38	50–75	F, Fig. 12.
	6	"				‡	‡	18	30–50	G, Fig. 12.
3.06	2	S.	100			90	78	90 (?)	60–80	
3.07	4	"	150			135	130	118	120	
3.12	6	"	220			185	165	150	175	
3.19	12	"	180 / 140			130 / 95	110 / 70	90 / 60	130	Trouble with pumps.
3.22	12	S., A.	190	250		160	135	130		
3.23	12	"	190	250		175	155	140	175	B, Fig. 12.
3.29	12	"	190	250		140 / 115	120 / 98	102 / 85	150	Race St. hydrant open. C, Fig. 12.
3.34	12	S., A., V.	150	220	140 / 170	125 / 130	102 / 109	92 / 97	150	Race St. hydrant closed.

(B) EXPERIMENTS WITH LINES OF 300 FEET OF 3½-INCH HOSE AND 2-INCH NOZZLES.

Time (P. M.).	Number of Streams.	Pressure Taken from	Pressure (Pounds per Square Inch). At Boat.* S.	A.	V.	At Race St.	At Broad St.† Idle.	Active.	Base of Play-pipe.	Horizontal Throw (Feet).	Remarks.
3.56	1	Belmont.				60	55			75	
	2	"				53	47			50	
4.03	2	S.	225			200	178		44 (?)	230	
	3	"	190							175	
	4	"	195						30 (?)	150	
4.14	4	S., A., V.	220	270	220	170	145		36 (?)	190	
	3	"	220	260	225	to	to		to	200	
	2	"	215	260	245					225	
	1	"	210	270	250	210	195		50 (?)	235	A. Fig. 12.
	1	"	170	250	190	150 / 140	155 (?) / 130			150	Race St. hydrant open.
	1	"	190	270	230					262	Race St. hydrant closed.

* S., "Stuart"; A., "Ashbridge"; V., "Visitor."

† The Broad Street hydrant or hydrants, from which streams were taken, are designated as "active"; the other, as "idle."

‡ The mercury gauges, on the Race Street hydrant and on the "idle" Broad Street hydrant, had no scales to indicate pressures under 45 pounds per square inch.

(C) EXPERIMENTS WITH HALE (KANSAS CITY) WATER TOWER, WITH 2-INCH NOZZLE 65 FEET ABOVE STREET, AND TWO 2-INCH "MONITOR" NOZZLES 4 FEET ABOVE STREET, CONNECTED WITH HYDRANT BY TWO 100-FOOT LENGTHS OF 3½-INCH HOSE.

Time (P. M.).	Stream.	Pressure Taken from	Pressure (Pounds per Square Inch).			Horizontal Throw (Feet).
			At Boat, S.	At Race St.	At Broad St.	
4.42	Top nozzle.	Belmont.		58	50	
4.45	"	S.	120	88	75	
4.46	"	"	230	180	180 (?)	
4.47	"	"	250	210	200	165 (?)
4.49	"	"	190	180	160	250 (?)
4.50	"	"	230	190	168	200 (?)
4.51	2 "Monitors."	"	235	200	175	150–200
4.53	"	"				250

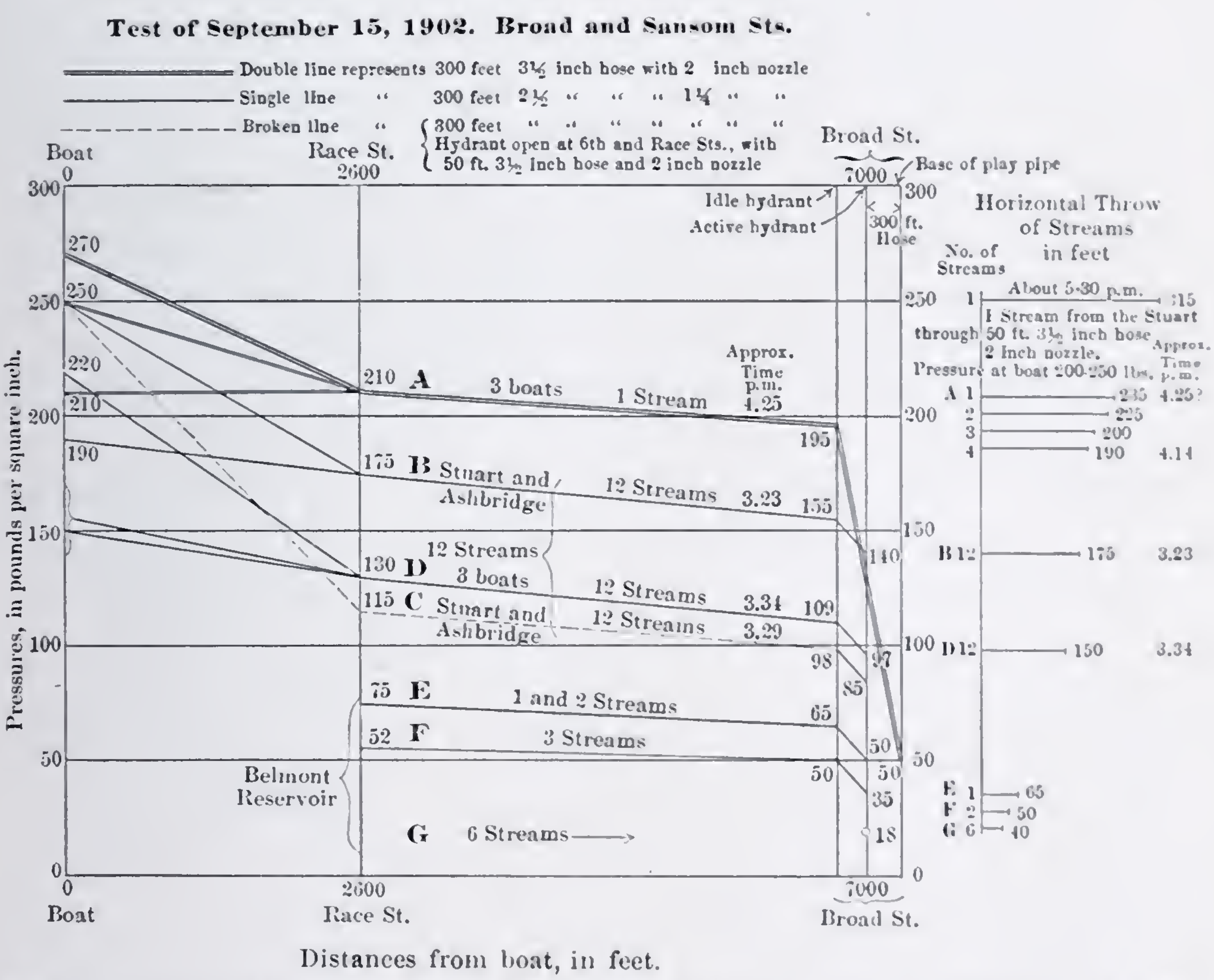

Fig. 12.—Philadelphia. Diagram of Pressures Recorded. September 15, 1902.

The five points for which pressures are shown are, respectively, (1) boat, (2) Sixth and Race Streets, (3) idle hydrant at Broad Street, (4) active hydrant at Broad Street, and (5) base of play-pipe at Broad Street. (See remarks above, respecting indications of pressures at base of play-pipe.)

Strictly speaking, a correction should be made in the diagram on account of difference of elevation between boat (about 0, city datum), Race Street (+ 28 feet), and Broad Street (+ 43 feet), but the error due to this is probably much less than the errors already noted, and due to insufficiency of apparatus provided, etc.

To the right of the diagram, the approximate horizontal distances to which the several streams were thrown are indicated to scale and in figures. These distances were read from marks, placed upon the ground previously to the exhibition.

Thus far, the Philadelphia fire main system has come into practical use on two occasions. The first of these was at the fire in J. E. Mitchell's cotton and wool warehouse, a five-story brick building at 124–126 Chestnut Street. This was on July 2, 1902, when, at 6.29 P. M., four alarms were sent in. Owing to the character of the contents of the building, the fire burning to the centers of the bales, where it was out of reach of the water, the ruins smouldered for a long time, and the new system played upon them, off and on, for thirty days. Chief Baxter, of the Bureau of Fire, considers this "the greatest exhibition ever witnessed of throwing water in a burning building."

The second occasion was on October 31, 1902, when, at 1.02 A. M., two alarms were received from the produce house of N. Canavan, 423 Delaware Avenue. Here the fire main system was in service for an hour, with very satisfactory results.

The following comparisons between the several fire main systems contain most of the data above given:

Date of First Installation.

Cleveland, 1888–1891.	Buffalo, 1897.	Chicago, not given.
Milwaukee, 1889.	Providence, 1897.	New York, proposed.
Detroit, 1893.	Boston, 1898.	Philadelphia, 1902.

System and Source of Supply.

Cleveland, 7 lines, from Cuyahoga River.

Milwaukee, 27 short lines, from arms of Lake Michigan.

Detroit, 17 lines, mostly on streets at right angles to Detroit River, including 3 lines of 2000 feet, and 3 lines of 1000 feet, Detroit River.

Buffalo, 1 line, from Buffalo River.

Providence, irregular loop. From high-service reservoir.

Boston, 1 line, from harbor to harbor. Salt water.

Chicago, 2 short lines. Extensions being laid. Source of supply not stated.

New York (proposed), several alternative gridiron districts, North and East Rivers. Salt water.

Philadelphia, 1 gridiron district, Delaware River.

Source of Pressure.

		Total Capacity (Gals. per Min.).
Cleveland,	2 fire-boats, 4000 and 7000 gallons per minute, (Both boats can be used on any of the lines.)	11,000
Milwaukee,	3 fire-boats, each 5000 gallons per minute, New boat under contract.	15,000
Detroit,	2 fire-boats, each 5000 gallons per minute,	10,000
Buffalo,	3 fire-boats, 4500, 5000, and 10,000 gallons per minute,	19,500
Providence,	high-service reservoir; pumping station contemplated.	...
Boston,	1 fire-boat, 6000 gallons per minute,	6,000
	1 fire-boat, 5500 gallons per minute, out of commission.	
Chicago,	not given.	
New York,	(Fire main system proposed.) 6 fire-boats, as follows:	

	Gals. per Min.	
"New Yorker,"	13,000	
"W. F. Havemeyer,"	3,000	
"Zophar Mills,"	6,800	
"Robt. A. Van Wyck,"	6,500	
"Seth Low,"	3,500	
"David A. Boody,"	6,500	
		39,300

Pumping station projected for one district.

		Gals. per Min.	
Philadelphia,	Fire-boat, "Stuart," 4 pumps, 2240,	8,960	
	Police boat, "Ashbridge,"	1,300	
	" " "Visitor,"	800	
	" " "Stokley,"	750	
	" " "King,"	1,200	
			13,010

Pumping station under contract.

Pressures (Pounds per Square Inch).

Cleveland, 250–275 at pumps; 70 and upward at hydrants, according to elevation, distance, and size and number of streams. Greatest elevation above river, 110 feet.

Milwaukee, 250 at pumps.
Detroit, 240 at pumps.
Buffalo, 300 at pumps, 180 at hydrants.
Providence, 116 to 85 at hydrants.
Boston, about 200.
Chicago, not given.
New York, proposed.
Philadelphia, 225 at pumps, 191 at farthest points.

Lengths, Diameters, and Kinds of Pipes; Coating; Joints.

Cleveland, 16,500 feet, 6-, 8-, and 10-inch cast iron, tar coated. Bell joints, leaded; double groove.

Milwaukee, 45,717 feet, 6-, 8-, 10-, and 12-inch cast iron, tar coated. Bell joints, leaded; single groove.

Detroit, 25,831 feet, 8- and 10-inch steel lap-welded Standard Oil pipe, tar coated, tested to 1000 pounds per square inch. Screw joints.

Buffalo, 6130 feet, 12-inch wrought iron, asphalt coated. Screw joints, leaded.

Providence, 29,400 feet, 12-, 16-, and 24-inch cast iron, tar coated. Bell joints, leaded; double groove.

Boston, 4700 feet, 12-inch (1 inch thick) cast iron. Standard tar and oil coating. Extra heavy bell and spigot joint, leaded; double groove.

Chicago, 2 short lines, 8-inch, laid, one in lumber district, one in South Chicago. Two miles 12-inch being laid in business district.

New York (proposed), first order, 8- 12-, and 14-inch; second order, 8-, 10-, and 12-inch; third order, 8-, and 12-inch; all cast iron.

Philadelphia, 13,000 feet, 8-inch; 20,800 feet, 12-inch; 6000 feet, 16-inch; total, 39,800 feet (7½ miles), cast iron, flange joints with 7-ounce army duck and Carolina tar.

Depth Laid; Protection against Freezing.

Cleveland, older lines laid 2–2½ feet, and drained after each fire in cold weather. New lines laid below frost-line.

Milwaukee, 3–4 feet. In winter, drain to river; a few to sewers.

Detroit, from 1 to 24 feet. Slope toward river for drainage. In winter, emptied after each fire.

Buffalo, 4 feet. Slope for drainage to sewer and river.

Providence, 6¼ feet. Kept full under pressure from reservoir. Flow maintained in winter by by-passes and blow-offs.

Boston, 5–7 feet below tide level. Always full of salt water, except at ends, which are exposed and are drained. Pressure maintained by small pipe connecting fire main with fresh-water tank on Post-office, with check-valve opening downward.

Chicago, not given.

New York, proposed. Salt water.

Philadelphia, 6 feet. Kept full under reservoir pressure of 70–80 pounds per square inch. No special provision for flow.

HYDRANTS.

	Number.	Diameter (Inches).	Average Distance Apart (Ft.).
Cleveland,	Not given	4 and 6	300
Milwaukee,	183	Not given	150–300
Detroit,	95	8 and 10	300
Buffalo,	25	8	250
Providence,	92	8	320
Boston,	14	6 and 8	250
Chicago,	Not given	Not given	Not given
New York (proposed),	Not given	Not given	150
Philadelphia,	166	$7\frac{1}{4}$	300

Cleveland, Wood pattern, cost about $70. Independent outlet valves.

Milwaukee, own pattern, cost $35 to $45. Independent outlet valves.

Detroit, three and four 3-inch outlets. Independent outlet valves. Gate valve to hydrant, with manhole. Detroit Machine and Valve Co. Weight. 1200 pounds; cost (latest pattern) $175.

Buffalo, Murdoch Valve Co., Detroit, $65. Gate valve to hydrant. Independent outlet valves.

Providence, Coffin Valve Co., flush pattern, $150. Gate valve to hydrant.

Boston, Boston Water Department post pattern, $44.50. Gate valve to hydrant; three $3\frac{1}{2}$-inch outlets. Independent outlet valves.

Chicago, particulars not given.

New York (proposed), cost $60. Three hose connections and one steamer connection.

Philadelphia, weigh 1000 pounds, cost $110. Gate valve to hydrant. Two 4-inch outlets. Independent outlet valves; 1-inch galvanized iron drain pipe to sewer.

AREA, LENGTH; COST.

			Cost (Dollars).		
	Area (Acres).	Length (Feet).	Total.	Per Acre, Protected.	Per Foot, Average.
Cleveland,	227*	16,500	41,000	180	2.50
Milwaukee,	630*	45,717	85,000	135	1.86
Detroit,	356*	25,831	Not given	..	..
Buffalo,	85*	6,130	23,700	279	3.87
Providence,	358	29,409	139,749	390	4.75
Boston,	65*	4,700	30,000	461	6.38
Chicago,	Not given	Not given	Not given	Not given	Not given
New York, proposed:					
District 1,†	100		110,000	1,100	
" 2,†	90		104,060	1,150	
" 3,†	273		300,000	1,100	
" 4,†	310		326,700	1,054	
" 5,†	2,400		2,400,000	1,000	

* Area estimated from length of mains, assuming protection to extend 300 feet each way from main.

† District 1, bounded by Chambers, Canal, Hudson, Broadway; District 2,

Philadelphia: *					
Trautwine, ...	87†	6,270	17,200	200	2.75
Darrach, ...	292†	29,356	176,130	603	6.00
Actual, ...	445†	40,000	300,000	674	7.50

The following graphic comparison of certain conditions, existing in the cities considered, shows that Milwaukee has the greatest length of mains laid and the largest fire-boat capacity of any city where fire mains are laid, and the lowest cost per foot of mains laid; while Philadelphia ranks next to Milwaukee as to total length of mains, and leads the list in the matters of total cost and cost per foot laid.

Total Fire-boat Capacity.

	Gals. per Day.
New York	39,300
Buffalo	19,000
Milwaukee	15,000
Philadelphia	13,010
Cleveland	11,000
Detroit	10,000
Boston	6,000

Total Lengths of Mains.

	Feet.
Milwaukee	45,717
Philadelphia	39,800
Providence	29,400
Detroit	25,831
Cleveland	16,500
Buffalo	6,130
Boston	4,700

Total Cost.

Philadelphia	$300,000.00
Providence	139,749.00
Milwaukee	85,000.00
Cleveland	41,000.00
Boston	30,000.00
Buffalo	23,700.00

Cost per Foot.

Philadelphia	7.50
Boston	6.38
Providence	4.75
Buffalo	3.87
Cleveland	2.50
Milwaukee	1.86

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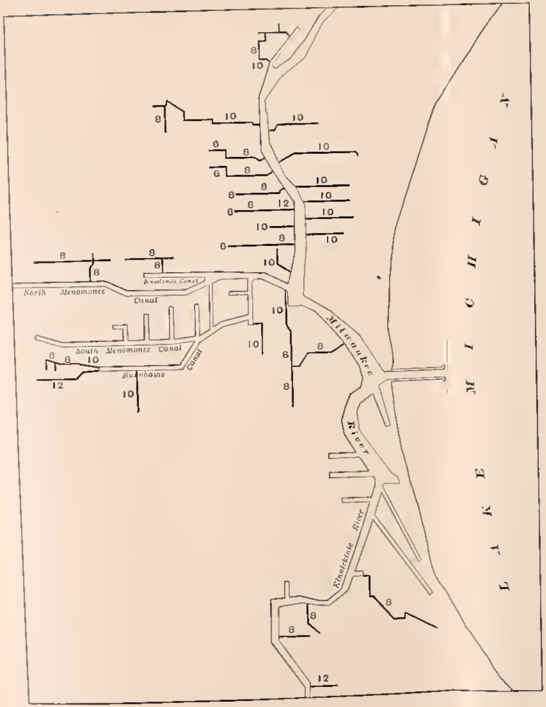
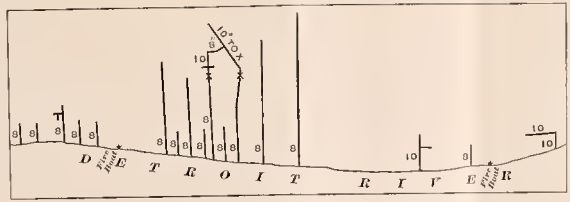
bounded by Canal, Bleecker, South Fifth Avenue, Broadway; District 3, Chambers to Battery, river to river; District 4, bounded by Division, Houston, Bowery, East River (pumping station); District 5, south of Twenty-third Street, river to river.

* Pipe line system only. Pumping station not included.

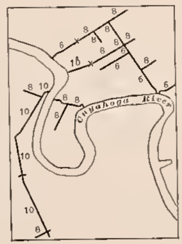
† See foot-note (*), p. 77.



Milwaukee.

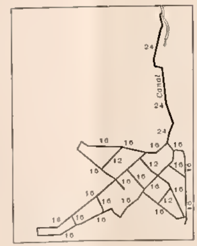


Detroit.



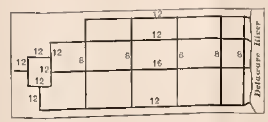
Cleveland.

Buffalo.



Providence.

Boston.



Philadelphia.

SKELETON PLANS OF EXISTING FIRE MAIN SYSTEMS. SCALE, 1 INCH = 3000 FEET. (PLAN OF CHICAGO SYSTEM COULD NOT BE OBTAINED.)

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New York
Buffalo
Milwauke
Philadelpl
Cleveland
Detroit
Boston

Milwauke
Philadelpl
Providenc
Detroit
Cleveland
Buffalo
Boston

Philadelp
Providen
Milwauke
Cleveland
Boston
Buffalo

Philadelp
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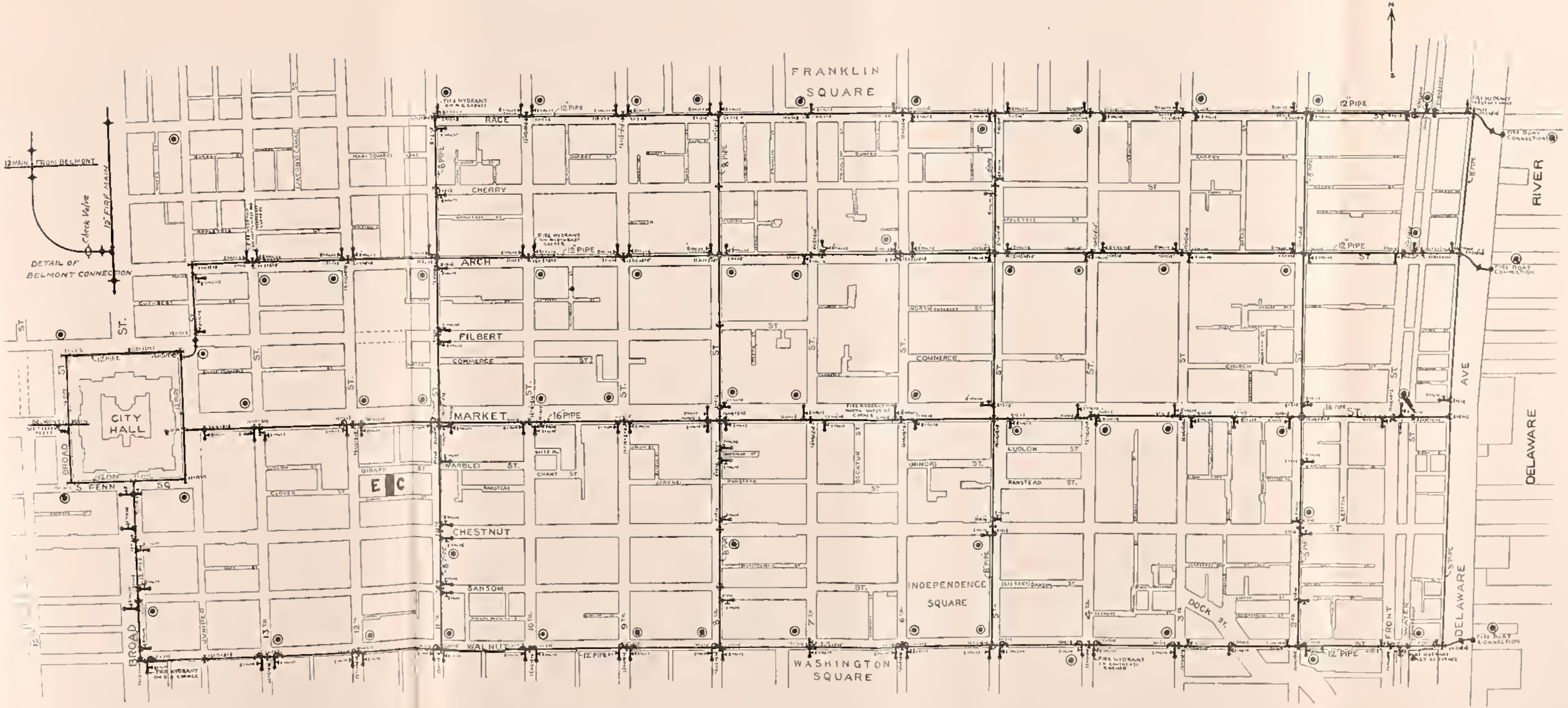
Providen
Buffalo
Cleveland
Milwauke



PLAN OF PHILADELPHIA FIRE MAIN SYSTEM. SCALE, 1 INCH = 484 FEET.

New York
Buffalo
Milwauke
Philadelp
Cleveland
Detroit
Boston

Milwauke
Philadelp
Providen
Detroit
Clevelanc
Buffalo
Boston

Philadelp
Providen
Milwauke
Clevelanc
Boston
Buffalo

Philadelp
Boston
Providen
Buffalo
Clevelanc
Milwauk

DISCUSSION.

Charles G. Darrach.—A tall building 300 feet away from the pipe line would be imperfectly protected with a pressure of but 50 pounds at the nozzle, and it would seem that the protected area should be estimated at a less distance than 300 feet from the outlying fire hydrants. It would seem that the properties on Chestnut Street have inadequate protection. There is no pipe on Chestnut Street. At the present time the pipes on the cross streets are laid on Second, Fifth, Eighth, Eleventh, and Broad Streets, the intention being, however, hereafter to lay pipes on all the remaining cross streets. The length of the blocks is about 450 feet, so that when all of the cross streets have fire pipes laid upon them, a building in the middle of the block would be at least 225 feet from the nearest fire hydrant. It will also be noticed that there are no fire hydrants in the middle of the blocks on Walnut, Market, Arch, and Race Streets. In my opinion, additional fire hydrants in the middle of each block would have been an improvement.

A Member.—In diagram A, how many nozzles were played and was that drop from one nozzle or all?

H. Wilmerding.—From one nozzle, 3½-inch hose and four lines going.

Mr. Darrach.—How much water was being pumped at that time?

Mr. Wilmerding.—I think 8000 gallons a minute.

Mr. Darrach.—Mr. Trautwine has covered the history of our fire pipe line so well that it is hardly necessary for me to enter into that subject. I have here drawings of some of the pipes and fittings designed for the Boston fire pipes, which may be interesting.

These pipes are cast iron, with lead joints. The sockets are provided with two rebates instead of one, as is the usual practice.

The first drawing shows sections of straight pipes, curves, sleeves, and branches which do not differ materially from the ordinary form of cast-iron pipe, except as to the rebates and thickness. The bell of the 12-inch pipe is 5 inches in depth, and the bell of the 6-inch pipe is 4½ inches in depth. The 12-inch pipe is 1 inch thick and the 6-inch pipe $\frac{7}{10}$ inch in thickness.

The second drawing shows connections of fire-boat with a 12-inch main. One drawing shows the form of construction of 12-inch pipe with two 10-inch flanged Y branch connections. Each 10-inch branch is provided with a Y having three branches 7 inches in diameter, each of which has two 4½-inch hose connections.

The third drawing is a detail of the fire hydrant. The hydrant has an 8-inch connection to the main and three 3-inch outlets, each controlled by valves.

The water flows from the fire main through an 8-inch branch to the base of the fire hydrant, enters the valve ports in a vertical line, and turns a right angle to the hose nozzle connection.

F. Schumann.—It turns a very sharp corner.

Mr. Darrach.—Yes, and no doubt would produce loss in pressure, especially when we take into consideration the high velocities. In connection with the high velocities of the water in the fire pipe lines, care must be taken in making leaded joints. If jute gaskets are used, as is the ordinary practice, the rapid flow of the water through the pipes has a tendency to pull the jute out of the joint. To prevent this, I have used a lead pipe gasket, having an outside diam-

eter of the clearance between the bell and the spigot. The pipe gasket is calked flat in the bottom of the joint before the gasket is inserted.

I cannot speak from experience in the use of cast-iron pipe with lead joints over 300 feet head. The use of cast-iron pipes with flanged joints on so extensive a system and under high pressures would, to my mind, be attended with some degree of risk, and I would favor the use of steel or wrought-iron pipe, with screwed joints, all of the pipes, sleeves, etc., to be treated with the Sabine japanning process, as was recommended for New York.

The original idea of the Philadelphia Board of Fire Underwriters was to cover the entire area from the Delaware River to Broad Street and between Race and Walnut Streets, with pipes on each of the east and west streets and on each of the north and south streets, pumping the water from the Delaware River. This scheme involved such a large outlay of money that it was decided to ask for a system with pipes on Chestnut, Market, and Arch Streets, with connecting lines on Fifth, Sixth, Twelfth, Broad, and Fifteenth Streets, with a pumping station at Arch Street.

The Arch Street line ran from the pumping station to Broad, on Broad to Filbert, on Filbert to Merrick, and on Merrick to Market.

The Market Street line ran from the pumping station to Front and Arch, on Front to Market, on Market to Juniper, on Juniper to South Penn Square, on South Penn Square to Merrick, on Merrick to Market, and on Market to Fifteenth.

The Chestnut Street line ran from Arch Street, on Delaware Avenue, to Chestnut, and on Chestnut to Fifteenth.

Branches were provided at each intersecting street, to allow for the future development of the system. Fire hydrants were located at the corners of each street and midway in each block.

The 12-inch pipe lines, including fire hydrants, were estimated in May, 1899, at $6.00 per running foot; 8-inch pipe at $5.00 per running foot. Before the work was started the increase in cost of material and labor, and the difficulties of construction, more than doubled the estimate.

To give an idea of the cost of construction in various cities, it is reported that 6200 feet of wrought-iron 12-inch pipe in Buffalo, including 26 fire hydrants and all appurtenances, cost $3.50 per lineal foot. The estimated cost for 4000 feet of cast-iron pipe in Boston was $6.00 per foot. An estimate made for New York by Mr. Foster Crowell, in December, 1897, for fire pipe lines complete, including mains, hydrants, etc., was $6.00 per foot for 14-inch pipe and $5.00 per foot for 12-inch pipe.

Carl Hering.—In looking at Mr. Trautwine's diagram, I was struck with the enormous losses in that system. In one case about 80 per cent. of the pressure is lost in friction, and a mere 20 per cent. is all that remains effective at the nozzle. These losses, of course, take place in the pipes and hose. If electric motors were used in place of boats, they could be located about the city in a great many places, so that the length of pipe through which they would have to pump would be very much smaller. But instead of running them from the lighting system, like the Edison, I would suggest for a city like this (and many others), which is provided with a network of trolley lines, that they be operated from the trolley system, the current from which would be a great

deal cheaper than from a system like the Edison. Moreover, when there is a fire it generally is the case that many of the trolley cars are idle, so that this extra and sudden load would not be added to existing loads. Without having made any detailed calculation, I think it would be safe to say that the amount of power which remains unused by the fact that the trolley cars are stalled, is more than enough to fight the largest fire.

THOS. C. MCBRIDE.—I understand that these enormous friction losses were only realized when the system was being tested for the greatest amount of water it would pass, and not when it was being tested in practical fire-fighting work. These particular tests are interesting only as showing the great amount of water which can be passed through a fire plug, manifold nozzles, etc., in using up the total pressure available as friction in these parts.

EUGENE M. NICHOLS.—I don't know that I can say anything new, but I happened to have a little experience in Cleveland, when they first started to introduce the fire-boat line, in connection with the superintendent of the waterworks in designing the first fire-boat hydrant used in Cleveland and afterward adopted in Milwaukee. I am not here to say anything in regard to the scientific part of it, but wish to make a remark in regard to the construction of the new line lately installed in Philadelphia. What struck me very forcibly was the last remark in reference to flanges and gasket joints instead of adopting the ordinary lead joints which for ten years had proved themselves entirely satisfactory and under fully as severe tests as they are likely to have in Philadelphia. At the upper end of some of those lines in Cleveland, when they have been pumping 300 pounds pressure from the fire-boat, it was 175 pounds at the hydrant. You will all agree that it is a pretty severe test for a joint, and they were just simply ordinary cast-iron pipe such as a manufacturer would make for use under 400 feet static head. The same pipe was adopted in Milwaukee except that they did not use the double groove. I never saw anybody calk lead joints more than an inch back from the mouth of the bell. I myself believe, from what I have seen, that a lead-calked line is more practicable for water than any gasket or flange joint that you can possibly get. Now, I simply call attention to a theoretical idea (sketch). There is a 12-inch pipe, flange 21 inches outside diameter, and only six bolts. There are two standards of flanges generally used by manufacturers—one called the standard of the Master Steam-fitters, or rather the standard adopted by the Master Steam-fitters, and the other, that of the American Society of Mechanical Engineers, designed for pressure of 150 pounds and less; and the prominent manufacturers have gotten together and adopted what they call the extra heavy standard, designed for pressures up to 250 pounds. In the extra heavy standard we have twelve bolts for a 6-inch flange. The Master Steam-fitters' standard, which is designed for 100 to 150 pounds, has only eight bolts, and outside diameter 11 inches. In 12-inch we use sixteen bolts, whereas in this design for heavy pressure they have only six; but I am getting away from the lead joint. I honestly believe that the city of Philadelphia has paid over 50 per cent. more for its pipe line than it ought to have done, and they would have been just as well off and just as safe as with the lines that have been used.

MR. JOHN E. CODMAN exhibited a lantern slide showing a picture of Fairmount

Waterworks, published in a magazine called the "Casket," some seventy-five years ago, and read the following extracts from the article:

"On the opposite page we furnish our patrons with a striking and picturesque view of the Water Works at Fair Mount, as seen from the Reservoir or Basin."

"Around and beneath him on the west, the spectator beholds the works connected with the Fair Mount Water establishment, one of the noblest triumphs of human industry and art, with its dam fourteen hundred and sixteen feet in length, creating a water power sufficient to raise into the reservoirs *ten million gallons* of water a day; the apparatus by which the water is raised into the reservoirs, and the reservoirs themselves, situated at the top of the Mount, at an elevation of one hundred and two feet above the low tide of Schuylkill, and fifty-six feet above the highest ground in the City of Philadelphia, covering an extent of more than three hundred thousand square feet, and capable of containing twelve millions of gallons of water. The pipes leading from these basins through the various parts of the city, extend at this time to the length of thirty-two miles, and are daily increasing."

"For a more particular description of these works the reader is referred to the January number of the 'Casket' for 1827."

MR. NICHOLS.—Mr. President, I would like to know if there is any one present who has had any experience in water-hammer breaking cast-iron pipe.

MR. DARRACH.—In my opinion the danger from water-hammer would be greater with cast-iron pipes than if wrought-iron or steel pipes were used. In one instance, at Manayunk, where there is a pressure of about 125 pounds, the closing of a fire hydrant burst the water-pipe.

MR. NICHOLS.—I have had some experience with wrought and steel pipe. Steel tube is much more likely to corrode in the earth than cast-iron pipe. I have taken out small wrought pipe which has been in some eight and ten years and entirely eaten through from the outside. That has been thrashed out pretty thoroughly by various engineers. At Milwaukee, more deeply, perhaps, than in any other part of the country, they had a great deal of trouble with cast-iron pipe being eaten with electrolysis. That could be overcome by a thorough bonding and getting the return currents back to the power-houses, without setting up electrolysis along the line. I believe it is pretty thoroughly understood that wrought-iron pipe is more likely to be attache.l than cast iron. I should hesitate somewhat about recommending wrought-iron or steel pipe laid under the ground, unless some particular pains were taken to preserve it from corrosion from the salts in the earth.

PHILADELPHIA HIGH-PRESSURE FIRE SERVICE.

JOHN E. CODMAN.

Read November 15, 1902.

WITHOUT going into details of ancient fire apparatus, or investigating those of other cities, I will at once take up the high-pressure fire service for this city in detail.

The advance of insurance rates in what is known as the "congested district" raised at once a demand from property owners for

FIG. 1.—HIGH-PRESSURE FIRE SERVICE PUMPING STATION, DELAWARE AVENUE AND RACE STREET.

a better fire protection than was afforded by the fire apparatus and the existing water-supply, which at best was barely enough to supply the fire steamers, and often not sufficient when two or more steamers were pumping from the same water main in one square.

The first step was for the Chief of the Bureau of Water to prepare

a plan, with an estimate of cost, for the Director of Public Works to submit to the Mayor, which he could recommend to City Councils, and ask for an appropriation to begin the work.

Several plans and projects were presented to the Mayor for his approval. One of the plans, which was very persistently pressed, comprising electrically driven pumps and underground reservoirs, was very fully described at a previous meeting of the Club. Another project, which was as strongly advocated by its inventors, to be mentioned for purposes of comparison, was the laying of a 48-, 36-, or 30-inch cast-iron main from the Roxboro Reservoir to the intersection of Broad and Market Streets.

I make the following excerpt from the report made upon this project by Mr. F. L. Hand, Chief of Bureau:

"A 30-inch pipe, delivering 17,000,000 gallons per day, will be a fair basis for comparison, as the intended fire service is computed to deliver over 10,000 gallons per minute, or about 15,000,000 gallons per day, with a reserve of 5,000,000 gallons for emergencies.

"The 36-inch and 48-inch mains are unnecessarily large for the purpose and will not be considered.

Length of 30-inch main from Roxboro Basin to City Hall and Market Street	46,000 feet.
Market Street to Delaware Avenue, 16-inch fire main,	5,658 "
Total, 30-inch and 16-inch mains,	51,658 " [9¾ M's.]
Amount of water delivered per twenty-four hours,	17,000,000 gals.
Height of water, Roxboro Reservoir,	414 feet C.D.
Height of water, City Hall,	40 " C.D.
Total net static head,	374 "
Loss of head in 46,000 feet of 30-inch pipe,	184 "
Total available head at City Hall,	190 "
Loss of head at Delaware Avenue,	90 "
Total available head at Delaware Avenue,	100 "
Cost of 30-inch main to Market Street, City Hall,	$313,720

Cost of Maintenance.

Cost of pumping 1,000,000 gallons into Roxboro Reservoir,	$15.73
Average amount of water used per day for fires, estimated,	2,000,000 gals.
Cost per year of 365 days,	$11,482.00
Cost of repairs and care of pipe, say	1,500.00
Total cost of maintenance,	$12,982.00

SUMMARY OF PRESSURE.

Pressure at City Hall from 30-inch main, ...	190 feet	= 82 lbs.
Pressure at Delaware Avenue from 30-inch main, ...	100 "	= 43 "
Pressure at City Hall from pumping station, ...	440 "	= 189 "
Pressure at Delaware Avenue from pumping station, ...	520 "	= 225 "

"I would respectfully call your attention to the great loss of pressure between the Roxboro Reservoir and City Hall, amounting to 184 feet, and to the additional loss to Delaware Avenue of 90 feet, caused by friction through 46,000 feet of 30-inch main and 5658 feet of 16-inch and 12-inch main.

"The Roxboro Pumping Station is now taxed to its full capacity in order to meet the demands of the consumption, and any further requirement from it would necessitate the purchase of another 5,000,000-gallon pump, at a cost of, say, \$30,000, and two additional boilers at \$9500, making a total of \$39,500 additional cost at the pumping station."

After giving each one a fair hearing and due consideration, the present plan, offered by the Chief of the Bureau of Water, was adopted. This comprises the construction of a permanent pumping station on the Delaware River front, with mains of sufficient capacity to deliver at least 15,000,000 gallons of water per twenty-four hours, or about 10,000 gallons per minute at the Public Buildings, Broad and Market Streets, with a pressure of 220 pounds at the pumping station. This plan originally contemplated a 20-inch main on Delaware Avenue or Water Street, with a 12-inch connection at Race Street, 12-inch at Arch, 16-inch on Market, and a 12-inch in Walnut Street, running out these streets to Broad Street and passing around the Public Buildings. All north-and-south streets were to be connected with 8-inch mains from Race to Walnut Streets. Steam pumping engines of 5,000,000 gallons capacity, and steam boilers were to be used at the pumping station. The following report, with plans and estimated cost of a water-supply for extinguishing fires in the congested district of the city bounded by Race and Walnut Streets, the Delaware River and Broad Street, was submitted to the Director of Public Works by the Chief of the Water Bureau:

"PHILADELPHIA, *April* 9, 1900.

"MR. WILLIAM C. HADDOCK, Director, Department of Public Works:

"*Dear Sir:*—In response to your verbal request, I have prepared the following plans and estimates of cost of a water-supply for extin-

guishing fires in the congested district of the city bounded by Race and Walnut Streets, and Delaware River and Broad Street.

"Quantity of Water Required.

"The quantity of water required is computed from the stated quantity discharged by the fire engines now in use. These engines, it is claimed, will discharge 500 gallons per minute through 100 feet of 2½-inch rubber-lined hose with a pressure of 100 pounds at the nozzle.

"This quantity is an average estimated on the theoretical capacity of the fire engines.

"It is proposed that the new system shall exceed the present one, in both quantity and pressure of the supply, and that it shall be designed to maintain continuously, for any desired length of time, both quantity and pressure.

"By the proposed plan the quantity of water available is the delivery of twenty streams of 500 gallons per minute, or 10,000 gallons per minute, which is equivalent to 14,400,000 gallons per twenty-four hours, at a pressure equivalent to a head of 520 feet on the pumping machinery, and to a head of 440 feet at the most distant fire hydrant in the system, and is in excess of any water-supply in use to-day for fire purposes alone.

"It is proposed to further increase this quantity by 33 per cent., or in the design of the pumping station to provide for 20,000,000 gallons per twenty-four hours, one-third of which will always be held in reserve in case of accident. Few persons can realize from the above statement the vast quantity of water that can be deluged into a building, provided it was all in operation at one time; 20,000,000 gallons per twenty-four hours is 1870 cubic feet per minute, which is equal to a room 10 feet deep, 10 feet wide and nearly 19 feet long.

"Location of Pumping Plant.

"The location of the pumping plant must be near the source of supply of water, and at a minimum distance from the extreme limit of demand upon the system.

"Fortunately Philadelphia has an abundant supply of water on both sides of the principal business centers, and a location can be secured on either river which will give an abundant supply of water for fire purposes.

"A location on the Delaware River front can be secured by taking property on Delaware Avenue, near Market or Chestnut Streets. No estimate has been made for this item, but undoubtedly a large sum of money would be demanded for a sufficient area for an engine house, boiler house, and stack.

"On the Schuylkill front a property belonging to the city, a part of the old gas works, situated between Market and Chestnut Streets, could be utilized for a pumping station.

"In considering this location, the extra cost of mains from the Schuylkill to Broad Streets, and the corresponding loss of head by friction in the pipes, will be offset by the cost of purchasing ground on the Delaware front.

"Either location will give the same results in the district under consideration, which is bounded by Race and Walnut Streets, the Delaware River and Broad Street.

"Pumping Machinery.

"It is proposed that the pumping plant shall be composed of four separate pumps of 5,000,000 gallons each, all of which can be used as one plant, in an emergency, or one or more pumps, as may be called for at ordinary fires; but one pump shall be continuously in operation, pumping into the mains and maintaining a constant pressure of not less than 225 pounds per square inch.

"The boilers should have sufficient steam-generating surface and capacity to furnish a supply of steam to start the whole plant into operation in the least possible time with ordinary chimney draft.

"Supply Mains and Fire Hydrants.

"The high pressure which it is proposed to use in this system necessitates a careful consideration of the material of which the mains are to be constructed.

"Cast iron is used almost exclusively for water mains at the present time, first, because of its cheapness; second, because of the facility with which it can be laid and the lengths connected without the use of skilled labor and material; third, because special shapes, pieces, and irregular forms can be readily made to meet the requirements of any position of the pipe.

"Cast iron possesses less than one-third of the strength of steel plate of medium steel such as is used in the manufacture of rolled steel pipe;

it has none of the elasticity of steel plate, but is naturally brittle and unreliable, and has, during the past ten years, been entirely superseded by structural steel in bridges, buildings, and all other work where cast iron was formerly used.

"Although given the most rigid inspection, cast-iron pipe breaks and bursts under even the light pressure to which it is subjected in this city, and causes untold annoyance and damage from outflowing water.

"The breaking of a 12-inch pipe in Market, Chestnut, or Walnut Street, under a pressure of 520 feet head, would, before the flow of water could be stopped, cause almost as much damage as a large fire.

"The increased demand for steel pipe and its more extended use have cheapened the cost of its manufacture, until, at the present time, it can be made and laid in the ground for not more (at a maximum price for labor and material) than double the cost of cast iron.

"It is proposed, therefore, in this system, to use rolled steel pipe, with rolled steel flanges, and to thus eliminate, as far as possible, every element of danger which the use of cast-iron pipe and connections would entail.

"Fire Hydrants.

"It is proposed to use steel pipe connections to the fire hydrants, and to design, if possible, a fire hydrant which shall be flush with the pavement, and which shall have one, two, or three hose attachments, so arranged that one, two, or three streams can be used from the hydrant at the same time.

"It is proposed to place a hydrant at the corner of each intersecting main street, and one or more near the middle of a square, at the corner of an intermediate street or streets.

"This will provide from 12 to 16 fire hydrants for each square, and from 32 to 48 hose attachments, all of which could be concentrated on one building, in an emergency.

"Cost of Proposed System.

"The following computation of cost is made on the above data, and does not include the cost of property taken or used for a pumping station:

PUMPING STATION AT FILBERT STREET, SCHUYLKILL RIVER.

Proposed pressure at pumps, 225 lbs. per square inch.

4 5,000,000-gallon pumps, at $30,000,	$120,000
8 boilers, at $4750,	38,000
Foundations, boilers, and stack,	12,000
Sub-foundations, pumps,	5,000
Engine and boiler house,	50,000
20-inch pipe, Market and Fifteenth Streets, 8060 feet, at $10.00 laid,	80,060
16-inch pipe, Market Street, 5280 feet, at $8.50,	44,880
12-inch pipe, Race, Arch, and Walnut Streets, 23,520 feet, at $6.00,	14,120
8-inch-pipe, north-and-south streets, Front to Broad Streets, 32,760 feet, at $5.25,	171,990
413 fire hydrants, at $50.00,	20,650
413 6-inch valves, at $23.00,	9,499
6 16-inch valves, at $200.00	1,200
24 12-inch valves, at $100.00,	2,400
104 8-inch valves, at $50.00,	5,200
Total,	$702,539

PUMPING STATION AT MARKET STREET, DELAWARE RIVER.

Proposed pressure at pumps, 225 lbs. per square inch.

4 5,000,000-gallon pumps, at $30,000,	$120,000
8 boilers, at $4750,	38,000
Foundations, boilers, and stack,	12,000
Sub-foundations, engines,	5,000
Engine and boiler house,	50,000
20-inch pipe, Delaware Avenue, 2340 feet, at $10.00,	23,400
16-inch pipe, Market Street, 5280 feet, at $8.50 laid,	44,880
12-inch pipe, Race, Arch, and Walnut Streets, 21,120 feet at $6.00	126,720
8-inch pipe, north-and-south streets, to Broad Street, 32,760 feet, at $5.25,	171,990
345 fire hydrants, at $50.00,	17,250
345 6-inch valves (fire hydrants), at $23.00,	7,935
6 16-inch valves, at $200.00,	1,200
24 12-inch valves, at $100.00,	2,400
104 8-inch valves, at $50.00,	5,200
Total,	$625,975

"COST OF MAINTENANCE.

"The basis for this computation is the data given by the Bureau of Water for the Roxboro Pumping Station, which is the station pumping at a pressure approximating that proposed for this system.

"The cost of coal is taken from the price per ton for coal delivered

at the Frankford Pumping Station on the Delaware River, and the quantity is approximately estimated:

Coal for one year, 3000 tons, at $2.00 per ton,	$6,000
Wages of 3 engineers, at $1000 per year,	3,000
Wages of 3 firemen, at $800 per year,	2,400
Oil,	400
Incidentals,	150
Repairs,	1,000
Total,	$12,950

"Very respectfully yours,
"F. L. Hand,
"*Chief of Bureau.*"

City Councils made an appropriation of $300,000 with which to begin the work. As this was only about one-half the amount required, the Director of the Department of Public Works and the Chief of the Bureau of Water, upon consultation, concluded to use the whole of the amount in laying the mains. They also made an investigation into the use of the fire-boats to utilize the mains until another appropriation by Councils could be made for a pumping station.

After visiting several cities and witnessing the successful use of fire-boats, it was concluded to adopt them for a temporary pumping plant to meet the urgent demands for an improvement in the fire service.

A specification was drawn for "Furnishing and laying steel or cast-iron water-pipe and all appurtenances for high-pressure fire service between Walnut and Race Streets, the Delaware River and Broad Street."

Proposals and bids were asked for on the original plans covering the above-named streets, except Chestnut Street, which it was found was already so completely filled with water- and gas-pipes, electrical and telephone conduits and sewers, that it was, without going to an enormous expense, almost impossible to lay the mains in the street. Provision for Chestnut Street was therefore made by connecting the fire hydrants from the north-and-south streets.

Upon opening the bids it was found that the Hoffman Engineering and Contracting Company were the lowest bidders on furnishing and laying the mains. After tabulating the results of the various items bid upon, it was found that by using cast-iron pipe and steel fittings, about 40 per cent. more cast-iron than steel pipe could be laid, and,

further, that nearly the whole district between Broad Street and Delaware Avenue could be reached by adopting the cast-iron mains.

It was intended to give steel pipe the preference, but the high prices quoted in the bids, which nearly prohibited its use, and the desire to cover as much as possible of the congested district with the limited appropriation, together with the greater liability of steel pipe to injury from electrolysis, overruled the preference for steel pipe.

In order to keep the cast-iron pipe and flanges to the standard used, the extra thickness of the pipe to meet the test pressure of 800 pounds per square inch was taken from the inside of the pipe.

To meet and overcome this loss of head in the smaller diameter of the pipe, it was decided to increase the pressure at the pumping station from 225 to 300 pounds per square inch, equivalent to a static head of over 700 feet.

In laying the cast-iron flanged pipes the subject of expansion joints was thoroughly considered. The practical experience of leaky expansion joints is well known. Various devices are contrived and patented to overcome this difficulty. Inquiries made of contractors laying miles of steel water mains elicited the information that no expansion joints were used. The resiliency of the pipe and the fact that it is not always in a straight line are found to be sufficient to meet the expansion due to the small change of temperature of the water in the pipe.

In the case of the cast-iron pipe the resiliency of the material in comparison with steel is almost totally lacking. Still, there is some, as indicated when a test-bar 24 inches between bearing points under a transverse load will bend from 0.30 to 0.50 of an inch before breaking.

In the case of the fire mains, the temperature of the water at no time, when taken from the river in the summer, at a distance of 3 to 9 feet below the surface, will ever be above 65° to 70° F., and in winter will not be below 45° to 40°. Taking the extreme case of 40° to 70°, a difference of 30° in temperature, cast iron will, according to various authorities, expand from $\frac{3}{4}$ of an inch to 1 inch, supposing it to be perfectly straight in 500 feet. The cast-iron mains were deflected in various ways from a straight line by curved pipe, and it was held that the expansion would all be taken up on the curves and bends, especially if these were to be made of steel pipe. The mains were laid without any special expansion joint being provided. Every 200 or 300 feet of pipe were tested to 400 pounds hydraulic pressure after being laid, and no trouble whatever found from expansion, although the pipe was laid in both extremely warm and cold weather.

Soon after the pipe was laid it was found that a length had broken near the flange bolting the lengths together. In the writer's opinion this was not due to the expansion of the pipe from a difference of temperature in the water, for the pipe was probably broken or very near the breaking-point before the water was turned in, but to the fact that in laying the pipe in the ditch, although extreme care was exercised in doing it, there was some settlement due to the weight of material filled in on the pipe and the heavy travel in the street directly over the pipe. This caused the pipe to settle unequally between fixed points, which would be the point at which a change of grade would occur and the pipe would assume a catenary curve, producing a bending strain on the flanges at the extreme points of the curve. The resiliency of the pipe, as previously stated, was very small; therefore the pipe was broken off and not pulled apart. To overcome this difficulty, recourse was had to lead-calked slip-joints, as the best expedient that could be found. One of the slip-joints is introduced into the main at every 400 or 500 feet and has proved, so far, very successful in overcoming the difficulty.

Immediately upon the awarding of the contract for the laying of the fire mains, attention was directed to a motive power at the pumping station other than steam for driving the pumps. Electrical current from outside sources was a first consideration, and the almost sure dangers of accidents at the power-house, electrical storms, fires on or near the supply wires, short-circuits, to say nothing of the fact that the whole fire-extinguishing plant would be under the complete control of outside parties over whom the city would have no authority. To build and equip a station for generating electrical power to drive the pumps did not present any advanage over the steam plant; in fact, it would only be an unnecessary repetition.

Gasolene engines were next considered, and the working of them at different places was investigated and found to be exceedingly successful and economical for small water-pumping plants.

The investigations on this line suggested to the Chief of the Bureau to make inquiries for gas-driven engines. The United Gas Improvement Company was communicated with and the information obtained that all the gas needed could be obtained from them. Correspondence was opened with all the gas or gasolene engine builders whose addresses could be found in engineering papers, asking for an engine of 300 horse-power or more. Answers were received stating that they had no engines running over 150 horse-power, but were perfectly willing to experiment on any amount of horse-power with the understanding that

the city would accept the results and they would be paid for their work, whether successful or not. This was not entirely satisfactory, and the matter stood open until the Pan-American Exposition at Buffalo was in full operation, when the Westinghouse Company put a 300 horse-power 3-cylinder gas engine on exhibition.

The satisfactory working of this engine was reported to the Chief of the Bureau, and a visit of inspection was made by the Director of Public Works and the Chief of Bureau. It was shown that this engine could be started and run up to its full capacity in less than one minute from the opening of the admission valve.

Large gas engines were not very common at this time (April, 1900), and it was decided to divide the pump capacity into smaller units. To pump 1400 gallons per minute or 2,000,000 gallons per day of twenty-four hours against a head of 300 pounds per square inch requires an expenditure of about 280 horse-power, or, say, an engine of 300 horse-power, which was the unit of capacity decided upon.

Considerable adverse criticism of a rather mild, non-committal character was made upon the adoption of gas engines. Without commenting on these criticisms, but in order to show the rapid advance that has been made in the construction and use of the gas engines, I present the following extract from a paper read before the British Association, September 11, 1902, and published in the London "Engineering":

"In England the first gas engines above 400 horse-power were only started in the year 1900, and they worked with Mond gas. One was a 450 horse-power Crosby engine and the other a 650 horse-power 'Premier'; both engines had two cylinders and were direct-coupled to large dynamos.

"Table 1, page 378, gives a classified list of large gas engines and shows a remarkable total of 327 gas engines over 200 horse-power, capable of supplying (at this time, August, 1902) 181,605 horse-power, 2000 horse-power being the largest built by the Snow Steam Pump Company."

Also the following from the "Iron Age" of November 6, 1902:

"One of the most astonishing things in Germany is the point to which they have developed the gas engine. At Differdingen can be seen blast furnaces having the blast supplied by blowing engine cylinders direct-connected to gas engine cylinders. These are in units of 800 horse-power each, and gas engine units may also be seen of 800 and 1000 horse-power direct-connected to dynamos, so that where there

are no steel works in connection with the blast furnace no steam boilers would be necessary. All this has been made possible by being able to clean the blast-furnace gas, the centrifugal principle being used. Water is mixed with the gas, the water and dust thus being separated out by an ordinary centrifugal fan. The gas, before going through the fan, carries 2.2 to 2.5 grains Troy per cubic foot, and afterward carries 0.175 grain per cubic foot. The gas mixed with water then goes through the scrubbers, which look like small blast-furnace stoves and contain different material, often water and wood fiber. The scrubbers remove a further portion of the dust, for after leaving them the gas

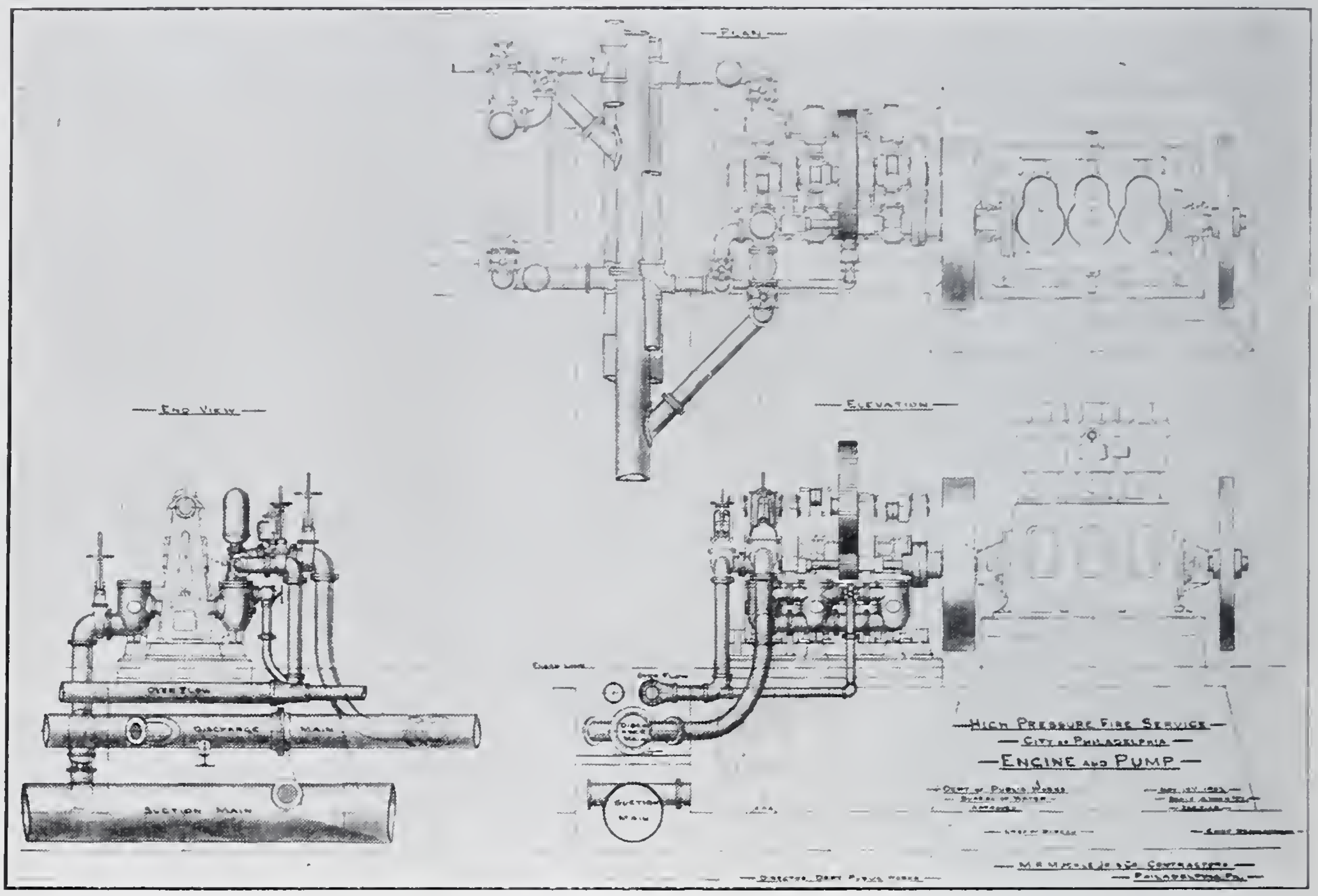


Fig. 2.

contains 0.044 grain Troy per cubic foot. A small jet burning shows by its color and appearance whether the gas is being properly cleaned. They use 0.03 to 0.06 gallon of water per cubic foot of gas. The gas contains 100 to 120 B. T. U.

"I was told by some of the engineers where large gas engines were running on blast-furnace gas that 105 to 125 cubic feet of blast-furnace gas were used per horse-power per hour, and that 6½ gallons of water per horse-power per hour were used for cooling the cylinders.

"Under variable load there seemed to be no difficulty in the various makes of gas engines to take care of it; and as to the economy, I was

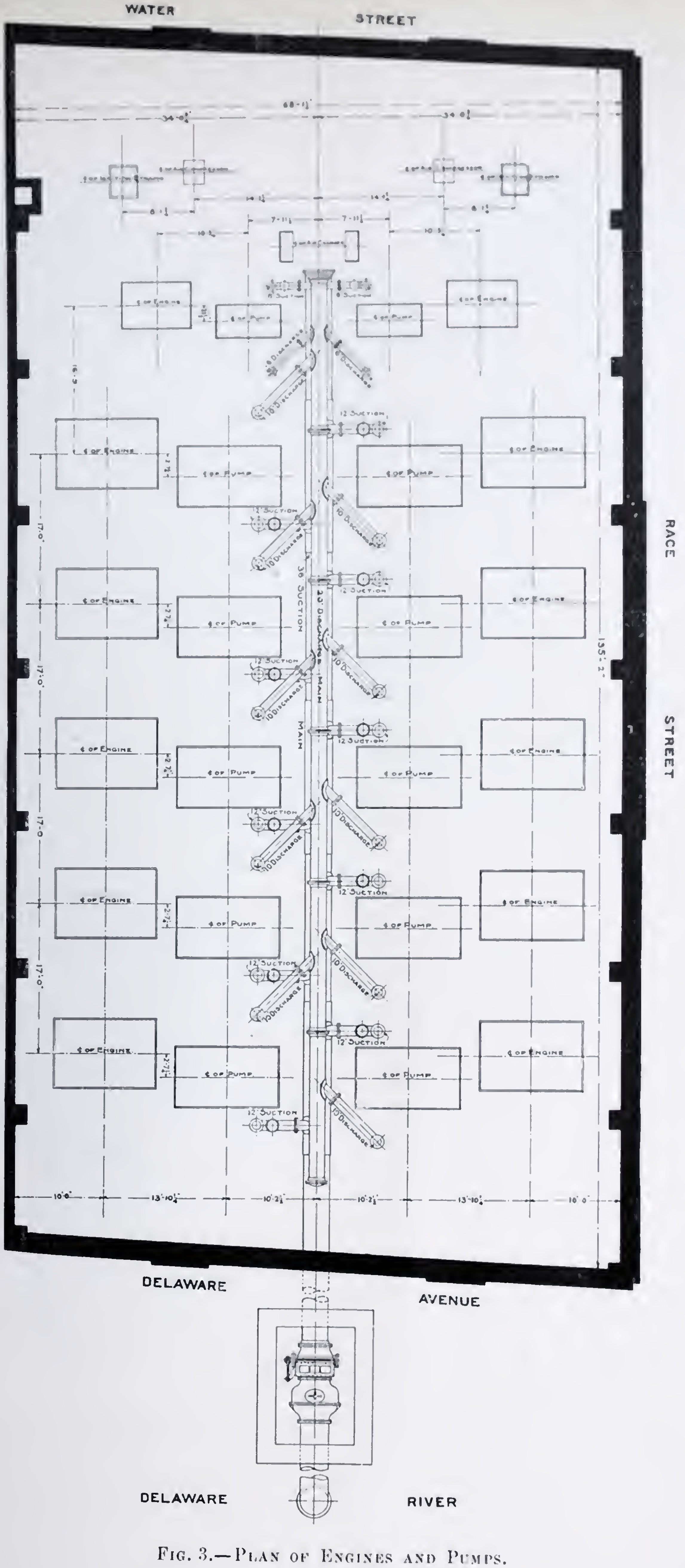


FIG. 3.—PLAN OF ENGINES AND PUMPS.

unable to obtain any figures bearing directly on this point, but the economy of the whole installation, as will be seen from the quantity of gas used, would not only take care of this, but would pay to clean the gas many times over if necessary, as I understand some of our American blast-furnace gas carries more dust than the German."

Specifications were drawn for engines and pumps attached, of 275 to 300 brake horse-power, specifying that the engines should be of the three-cylinder, four-cycle type in preference to a four-cycle single cylinder, the three cylinders giving an impulse at least once in every rotation, the attached pumps to be three-cylinder also; the speed of the engines, when operating at a load of 275 horse-power, not to exceed 200 revolutions per minute, and shall be geared to the pumps in the proportions of 5 to 1. To avoid bids from experimentally disposed bidders, the following clause was inscribed in the specification: "56. The Director of Public Works desires it to be understood that he will not try or accept anything experimentally, nor use the first engine of its kind built by any manufacturer." Proposals and bids were asked for and received, and the contract was awarded to M. R. Mucklé, Jr., & Co., for 9 Westinghouse gas engines and Deane pumps.

Other objections to gas engines were very soon raised, the principal points being the greater first cost and greater expense for gas.

The following report in answer to these points was made to the Director:

"PHILADELPHIA, *October* 15, 1901.

"MR. WILLIAM C. HADDOCK, Director, Department of Public Works:

"*Dear Sir*:—In compliance with your instructions, I have prepared the table attached hereto, showing the comparative cost of running a plant for the high-pressure fire service with steam or with gas engines.

"The first cost of a gas engine and pump is greater than that of a steam engine and pump, but the additional cost of boilers and stack, for the latter, neither of which are required for a gas engine, makes the total cost of the two plants nearly equal.

"In the computation for the steam plant the coal consumed is reckoned for the whole month, with steam pressure on the boilers all the time, but with the engine running for only ten hours each month.

"The cost, therefore, of running the steam plant, per hour, for coal consumed, must include the coal used in raising steam and in keeping it at the required maximum pressure, or $50.00 per hour for a run of ten hours per month.

"The gas plant will require gas for the hours run only, as when the

engines are standing no gas will be consumed. Ordinarily a large fire would not need the full capacity of the station for perhaps more than three or four hours, at a cost of $39.20 per hour.

"In both cases engineers and firemen must be on duty all the time, and extra help can be detailed as required. The steam plant will require the services of three engineers, three firemen, and three oilers; the gas plant, of three engineers and three oilers only.

"The cost of running, per year, will show a much greater difference in favor of the gas engine than is shown in the table, from the fact that gas is used only when required, which might be considerable less than ten hours per month. Coal for the steam pump must be burned continually, all the year, and steam kept up, at the maximum pressure, for immediate use. The table is computed, as nearly as possible, for ten hours in each case. Any increase in running time will be proportionate in both cases.

"Yours very respectfully,
"F. L. Hand, *Chief of Bureau.*"

TABLE SHOWING COMPUTED COST OF RUNNING STEAM PLANT FOR HIGH-PRESSURE FIRE SERVICE, FOR ONE FIRE PER MONTH OF TEN HOURS' DURATION.

Number of Engines.	Number of Boilers.	Cost of Engines, Boilers, and Stack.	Total Capacity in Million Gallons per Twenty-four Hours.	Wages per Month.	Cost of Coal per Month.	Oil, Waste, etc.	Repairs.	Total Cost per Month, One Fire, Ten Hours.	Cost per Year, One Fire per Month, Ten Hours.
3	8	$140,000	15	$650.00	$500.00	$48.00	$85.00	$1283.00	$15,396.00

TABLE SHOWING COMPUTED COST OF RUNNING PLANT COMPOSED OF GAS ENGINES FOR HIGH-PRESSURE FIRE SERVICE, FOR ONE FIRE PER MONTH OF TEN HOURS' DURATION.

Number of Engines.	Cost of Engines, Boilers, and Stack.	Total Capacity in Million Gallons per Twenty-four Hours.	Wages per Month.	Cost of Gas per Month.	Oil, Waste, etc.	Repairs.	Total Cost per Month, One Fire, Ten Hours.	Cost per Year, One Fire per Month, Ten Hours.
8	$150,000	16	$450.00	$392.00*	$48.00	$85.00	$975.00	$11,700.00

* Cost of gas for ten hours.

The engines are to be started with compressed air in one cylinder with the relief valves on the pumps open. These valves are controlled by electric motors operated from the engine platform, one motor on each valve.

The entire work of operating the engines, pumps, and valves will be under the immediate control of one person who, from the gallery of the engine, without moving from his position, will open and close all valves; in fact, all the operation of starting and stopping will be by means of electrical currents.

The division of the pumping plant into comparatively small units presents an advantage in connection with telephone communication with all parts of the fire district, in increasing or decreasing the quantity of water required at a moment's notice.

The pumps will be three-cylinder, double-acting, driven from one shaft with spur gear and pinion to the engine.

The engines are geared directly to the pumps through the spur or pinion without friction clutches, in the proportion of 5 to 1; this, with the moderate rate of piston speed of the engines, gives a slow piston speed to the pumps. The suction pipe of the engines will be riveted to a 36-inch steel suction main crossing Delaware Avenue to the river, turning down at the bulkhead and extending about 3 feet below low tide, and provided with check-valve and stop-valve.

No attachments for automatic sprinkling arrangement or for private fire-extinguishing appliances will be made to these mains. The City Fire Department will thus have entire control of the high-pressure fire system upon its completion.

Plans have been prepared for a pumping station. The lot 138 by 71 feet, at the corner of Race Street and Delaware Avenue, having been condemned by the city for this purpose, proposals and bids were asked for and the contract awarded for this work to Messrs. Henderson & Co., of this city.

The engine house will be provided with a hand-driven traveling crane of 6 tons capacity, traversing the whole length of the engine room. The heating of the building is not contracted for, provision being made for a portable steam boiler and direct radiation.

The total amount under contract and expended for mains already laid is as follows:

Mains, engines, and engine house,	$608,802
20-inch pumping main,	37,000
Total,	$645,802

DISCUSSION.

The President.—Do any of the members present wish to make any remarks on the subject?

John C. Trautwine, Jr.—I am very glad that Mr. Codman has supplemented my imperfect paper with the more complete data which have just been laid before us, and especially that he has brought up the question of the expansion joints. It will be remembered that the introduction of those joints caused a good deal of newspaper talk, and also some discussion in the Club. About that time a reporter for one of our daily papers called and asked me to express my disapproval of the course followed by the Bureau in laying these mains without providing for expansion and contraction, which the reporter thought any novice ought to recognize as necessary. I need hardly say that, in the absence of opportunity for conference with the Bureau engineers, I refrained from passing judgment upon their methods.

I understand, from Mr. Weaver, who has charge of the work, that all breaks discovered in the mains, occurred near the summits of grades, a fact from which he concludes that they were due to the drag on the upper lengths of pipe; also, that in all cases they occurred directly under a flange.

James Christie.—Cast-iron pipes are apt to be fractured by unequal settlement, developing severe transverse strains. Of course, if the internal pressure is high the risk of breakage is increased, and under these circumstances the metal should be much thicker than normal consideration would seem to require, to cover the probable but unknown element of unequal settlement.

It is not probable that temperature changes exercised any serious influence, as rigid flanged joints on long stretches of water-pipe have been used without trouble from this cause. I know of no form of expansion joint adapted to the situation that could be depended on to relieve expansion and contraction.

Regarding the gas engines, the introduction of large-powered units is becoming quite common. In this country the development has been furthered by the extensive distribution of natural gas. The economical advantages are considerable, as even with ordinary producer gas results are obtained of double the power derived from similar fuel, operating through steam boilers and fairly economical compound condensing engines. The defects in the gas engine are mechanical and due to the conditions which so frequently hamper the designer. For instance, in the engines pictured by Mr. Codman, with internal cranks and a shaft continuous over several bearings, if great care is not taken to maintain accurate alinement trouble may be expected; also, the man is entitled to our sympathy who has to reach the cross-head pins, in case of heating or other distress.

When gas engines are produced that are equally free from mechanical defects, as the steam variety, they will run the latter a close race in the struggle for supremacy.

Mr. Codman.—Every engine has a relief valve, and there is a large air chamber on the 20-inch pumping main out of the station, 17 feet high and 5 feet in diameter. The pressure in the main would be enough to prevent the air from expanding sufficiently to go down into the main.

It was specified that the shafts shall be made of compressed steel, and the pinions of cast steel.

From our knowledge of the construction and the work required, we thought the more bearings, the better for the shafts. Triple cylinders were specified because we are under the impression that with this high-pressure a single-cylinder, four-cycle type, would not give as good satisfaction as three cylinders of the four-cycle type forming one driving engine. With a three-cylinder engine an explosion occurs at about two-thirds of a revolution, while with the single cylinder, of which designs were presented, only one explosion is made to every two revolutions. When we asked for these engines there was not one we could get over 300 horse-power each. Since then I read in the engineering papers that over 2500 horse-power are quite common.

Edwin F. Smith.—Referring to the weakness of the crank shaft of these engines, it is my understanding that they would not be run continuously and would not be subjected to such hard use as engines operated, for example, in steel mills working continuously throughout the week. They would be operated only occasionally when called upon to perform fire duty, and therefore this weakness in the shaft would be longer in coming on than it would in an engine operating continuously. For the service for which it is intended to be used by the city of Philadelphia, I think that this type of engine can be relied upon to do all the work that is required of it.

Henry H. Quimby.—Referring to the matter of the difficulty of thermal changes in the pipe, I understood Mr. Trautwine to say that the fractures in the pipe occurred on summits of grades, and also that the fractures were on the under side of the pipe.

Mr. Trautwine.—Right under the collar.

Mr. Quimby.—The inference was that the fractures were due to the tension of contraction, and I should think that it would cause them to take place in the upper side of the pipe. Considering the effects of thermal changes, the author said that the extreme range of change in length in 500 feet would be practically 1 inch. The pipe was presumably laid at mean temperature, therefore the greatest change to occur in it would probably be half an inch in 500 feet. I do not remember now what the modulus of elasticity of cast iron is, or ought to be, but probably a change of half an inch in 500 feet of cast iron would represent less than 2000 pounds per square inch in tension, and if there are no internal stresses nor flaws in the castings the castings ought to stand that pull; therefore, I feel like justifying the original judgment of the Water Department in not providing expansion joints for changes in temperature. If the packing of the earth furnishes that much resistance, should the iron not stretch enough to prevent breaking?

Mr. Codman.—It was conceded that no expansion joints would be required. The pipe is not a straight line, and the amount of expansion in a distance of 500 feet is trifling; no provision was made for it. The pipe, when laid in the street, no matter with what care, settles and assumes a catenary curve. There is very little resiliency in the pipe; the flange, being a fixed joint, would naturally break off instead of pulling apart, as by expansion.

Mr. Trautwine.—Was I right in understanding Mr. Weaver that all breaks

occurred near the summits of grades, and did the cracks appear generally on the top of the pipe or on the bottom?

Mr. Codman.—It didn't show which side.

Mr. Trautwine.—I think he said they all occurred under the flange near the end of the pipe.

Mr. Codman.—Yes. (Blackboard illustration.)

Francis Schumann.—Were the faces finished entirely across?

Mr. Codman.—Yes. There is a piece of cotton duck, about what you might call a light grade, soaked in North Carolina tar, put in between both flanges and screwed up with 1⅛-inch bolts. The bolts are not more than 2½ inches apart in the flanges, which are perfectly plain.

Eugene M. Nichols.—Why didn't you use bell and socket leaded joints all through instead of flanged joints?

Mr. Codman.—They blow out, and give way under 50 or 60 pounds pressure, and leak pretty badly. I think a great deal of difficulty would be found under 300 pounds pressure. I do not think, in my own private opinion, the leaded joint, under the pressure we want to carry, would be satisfactory.

Mr. Schumann.—I desire to add to the remarks of Mr. Christie regarding the gas engine that few engineers realize the great advances recently made in their design and completeness. The construction and satisfactory operation of gas engines of 2000 horse-power capacity is an established fact. In our own country engines are being built in which an impulse occurs at every stroke, as in a steam engine, the starting of the engine, from rest, being attained by compressing the mixture, for the first or initial stroke by an auxiliary compressor or pump ,worked by hand or power, the following or return stroke compression being by the regular operation. I feel certain that the gas engine, in connection with the development and introduction of the modern coke oven, with its enormous gas-producing capacity and the evolution in the transportation of liquid and gaseous fuel through pipe lines considerable distances, will result in the supersedence of the present steam engine and its boilers.

SOME ELECTRICAL FIRE HAZARDS.

WASHINGTON DEVEREUX.

Read October 18, 1902.

THE subject that directs our attention this evening is one of vast importance to all, regardless of whether they be the consumer or non-consumer, the lighting or power company, the telephone or telegraph company, or the insurance companies.

Not much has been written upon this subject excepting by the insurance fraternity, for, while the facts remain the same, the effect of stating the true condition of affairs would have discouraged many in the use of electricity as an illuminant or for power purposes. To-day, the general public is better acquainted with the facilities afforded by the use of electricity and with the dangers involved in its abuse, and in consequence they assist materially in the advancement of this source of power. That this assistance may become of more value is most heartily looked for, and an examination of some of the causes that may create a fire from electricity may be the means of educating the public to this desired state. We may reduce the causes to:

1. Short-circuit, in which the current is impeded in its desired course.

2. A leak, in which the current flows over or takes an undesirable course.

3. The contact with parts which have become heated by the flow of current, which may be, at the time of heating, a part of the circuit from the source of supply to the consuming device.

The first cause, a short-circuit, may be defined as a circuit of low resistance. This definition is not self-explanatory, for we may have a low resistance, which resistance could be made up of any number of resistance devices connected in multiple and doing useful work, the joint resistance of which may be very low.

To enlarge upon the previous definition, we may clearly define a short-circuit as a circuit of low resistance by which the current is impeded in its desired course, and from which we derive no benefit.

The second cause, a leak, may be of high or of a comparatively low resistance. In either case it must be treated as an undesirable consuming device attended with its many dangers.

The third cause does not require any further explanation, for our daily experience with heat from any cause, and its effect upon bodies in contact with it, is the best demonstration of its danger.

Before examining the causes denoted, it may be well to bear in mind that any one of the causes may occur in any part of the circuit, which circuit involves any part of the generation, the transmission, or the translating of electric current.

The most simple case of a short-circuit is that in which two wires of the same circuit and of opposite polarity, and between which a difference of potential exists, are brought into electrical contact. The result of such contact is to allow an amount of current to flow sufficient to melt the fuse or to open a protecting device, or to heat the wire to its melting-point.

It may be readily seen that a short-circuit can occur in any part of a circuit, which circuit has been defined, irrespective of the difference of potential.

Experience has shown us that in the majority of cases the protecting devices, by which is meant the fuses and circuit breakers, will be affected and will open the circuit, but it seldom occurs until after the damage to the troubled part is effective.

We see examples of the effect of a short-circuit in which the generator, the storage battery, the switchboard, the line, the transformer, the motors, the lamp, and the operating and protective devices have been destroyed beyond repair and in some cases beyond recognition.

Several large central station fires have occurred primarily due to a short-circuit. One case worthy of mention is that of a lighting station in which an arc started at the bottom of the alternating switchboard, simultaneous with a short-circuit of an alternating generator.

An effort was made by the attendant to disconnect the exciters and the alternator from the circuit, but the effort proved futile, owing to the great heat attending the arcing which had spread over the entire board. In an instant the other alternators were short-circuited and the station doomed to destruction.

Another case is that in which a chain hanging from a crane made contact with the exposed live parts of a trolley power generator, causing a short-circuit. The heat attending the short-circuit was sufficient to melt the metal, which dropped to the floor, resulting in quite a disastrous fire. From the same cause we find the destruction of motors, irrespective of the source of supply or of the nature of the work to which they may be applied; of incandescent lamps due to the

crossing of the filaments, the connecting wires, or the base of the lamp; of arc lamp on low-potential systems; of sockets, switches, cut-outs, flexible cords, wiring on gas and electric fixtures, each of which may result directly in a fire.

The second cause, that of a leak, is possibly one of the most treacherous factors we have to contend with.

A leak, resulting in the flow of a current, may be so small that it will not affect the smallest protective device on the line. Its work is slow and in almost every case destructive, and does not necessarily appreciably heat the wire unless the line is excessively fused, in which case there may be an excessive flow of current.

This leak can exist at any point and is usually due to dampness; it is difficult to test for and locate, as its condition varies with atmospheric changes or other causes that may vary the moisture which may exist on any insulating material.

When due to dampness, this leak is the result of a combined electrochemical action, which we know is attended with more or less heat.

The process of electro-chemical decomposition may be more correctly termed electrolysis. Unless interrupted, its ultimate end is to destroy the insulating properties of substances that are in contact.

A case in point is that of the charring of wood molding directly the result of dampness, in which there is a surface conduction of current. This will eventually change the wood into a more combustible substance—that of charcoal. Being a comparatively good conductor of electricity, the current flowing may be sufficient to heat and ignite the charcoal, or it may be ignited by an arc.

This electrolytic action affects metallic substances wherever encountered. In many cases the so-called verdigris, a direct result of electrolysis, covers switchboards, switch bases, and cut-outs, rendering this otherwise insulating surface a conductor of electricity, further increasing the action and heating the affected parts. Sufficient heat may and has been developed to rupture the insulating base, consisting as it may of either slate, porcelain, or marble, and permitting the actual contact of the switch blades or fuse lugs resulting in a short-circuit.

Electrolysis acting upon conductors will eventually reduce the cross-section of the conductor to such a small area that it is no longer safe to carry the normal current. In some cities considerable damage has resulted from underground electrolytic action, namely the de-

composition of water and gas-pipe lead armor of telephone and telegraph cables.

Probably the most favorable condition for electrolytic action in connection with interior wires is that in which two wires of opposite polarity are incased in wood molding, each wire being properly located in its own groove and the molding properly capped. By means of a mop or broom the molding near the washboard is sprayed with washing-water which is more or less impregnated with alkalies. The surface of this molding then becomes an excellent conductor of electricity, and the result is that which I have already explained.

In another instance electrolytic action set in between conductors incased in an iron conduit (unlined) and was carried to such an extent that the insulation broke down, causing a short circuit, welding the conductors and puncturing the conduit.

Grounding will eventually produce the same condition of affairs. By grounding is meant that there is an electrical connection between a conductor and the earth, or between the conductor and some conducting material that may be partially insulated from the earth. In either case, intended or not, there is a difference of potential between the insulated conductor and the earth, or between the partially insulated material and the earth. The accidental grounding of the other side of the circuit will produce a leak or short-circuit, inviting an undesirable condition.

In one instance, a frame house, supplied with gas, was wired and connected for the supply of electric current. A flexible drop cord was hung in front of a bureau between two windows. A gas bracket was located beside one window, the pipes to supply the brackets being run under the window, but inside the framework, a joint in the pipe being made directly under the window. A fire occurred and an examination justified the following conclusions: The flexible cord had been hung over the gas bracket; the handling of both the cord and the bracket had resulted in the removal of some of the insulation of the cord, thus making an electrical connection between the gas-pipe and the bare wire; the current was carried to the gas-pipe joint; the contact, being electrically poor, created an arc, punctured the pipe, and ignited the gas. Another example is a case of a poorly grounded conduit system in which either positive or negative wires become grounded to the iron conduit, and in which event the conduit becomes of the same polarity as the grounded wire, and there will then be a difference of potential between the grounded

pipe and the earth, or the other polarity of the system, ever ready to close the circuit, creating a cross- or short-circuit. The same condition is possible in metal ceiling construction.

On very large systems, as for example a three-wire underground system supplying current over a large district, it is impossible to maintain a perfect freedom from grounds, the leakage to earth being through the insulation and the tubes, the service, junction, and feeder boxes. On such a system it is practically impossible to make use of a ground detector, on account of this leak being general. Such a ground or leak practically connects every underground pipe service to this system.

In connection with the supply of current to combination gas and electric fixtures, where it becomes necessary to attach the wires to the gas-pipes, it would be dangerous, if not disastrous, if the insulation should break down, piercing the gas-pipe and igniting the escaping gas. It may be well to note here that trolley systems have a ground return and maintain a difference of potential of about 550 volts between the trolley wire and the rail.

The high-tension series arc light system, whether underground or overhead, furnishing a constant current of 9.75 amperes, the potential of which may vary from 500 to 6500 volts, is a source of danger, for, in the event of two grounds, the arc produced may be a powerful one and, should a break occur in the line, an intense and a long arc may be obtained at that point.

If the primary and secondary coils of a transformer come into contact electrically, the high-voltage primary current would flow to the secondary system, which is entirely unsuited to such high pressure.

There is still another hazard in connection with overhead lines—that of discarded wires. These wires, no longer in service, but retained in order to maintain the right of way, cross and lie upon roofs of buildings or hang in an unsafe condition from a structure, and in some cases, such as telephone, telegraph, and call wires, are actually connected to gas- and water-pipes in tenanted or unoccupied buildings. The other end of these discarded wires may be hanging promiscuously and, possibly, due to corrosion or rusting of the wire or its holdings, fall and cross wires carrying current at a high or low voltage. In consequence, the current is carried through the discarded wires to ground, whether it be gas- or water-pipes, metal roofs, cornices, or awnings, and may be sufficient to melt the wire or cause an arc at some comparatively high resistance point, creating a most favorable condition for far more serious trouble.

The third cause is that in which an inflammable material is permitted to come into contact with parts of a circuit that have become heated. This cause may be divided into two classes: that in which insulation is the material, and that in which a material exists, but adds nothing to the benefit of the circuit. It is obvious that there is no necessity for these distinctions, for the result is ultimately the same and will be treated as such.

In the manufacture and distribution of electrical energy there is a loss by heating due to the fact that all substances have a resistance which has to be overcome and which represents a loss in energy, which is substantially all transformed into heat. The heat which is produced in a wire only depends on the number of watts expended electrically by the current in overcoming the resistance of the wire, which resistance varies with different materials, and goes to raising the temperature of the conductor and indirectly that of the surrounding bodies; and this rise continues until the rate at which heat is lost equals that at which it is generated; then the temperature becomes constant. It is obvious, therefore, that an electrical conductor is only capable of carrying a certain current with a given elevation of temperature, and, practically, the allowable temperature is limited by consideration of injury to insulation and the danger of fire.

The temperature elevation of a wire for a given current strength depends upon its resistance, diameter, covering, and its surroundings. A copper wire carefully insulated by a thin coating of water-proof material and placed in still water is usually kept comparatively cool, owing to the rapid conduction of heat through the insulated cover into the water.

The same wire, carrying the same current, but suspended in air instead of being immersed in water, will usually attain a considerably higher temperature, as still air does not carry away heat from the surface of the wire so effectively as still water. For the same reason a wire buried in the ground will, in almost all cases, be found to be cooler than where supported in the air. A covering of, say, cotton, rubber, or other electrical non-conductor will, up to a certain thickness, serve to cool the wire by increasing its surface.

The same heating conditions would apply to switches, switch or fuse lugs, bus-bars, commutators, and in fact to any current-carrying parts of a circuit, and it is therefore necessary that they be sufficiently heavy to carry the required current without undue heating.

Heating may be the result of insufficient contact surface, and the

tendency in all cases is to increase the temperature to a dangerous point, or to melt and ignite the insulation of an inflammable nature, such as rubber and cotton. It is necessary, therefore, that the carrying capacity of current-carrying parts and of contacts shall be limited.

Poor connections at fuse blocks may produce heat enough to cause the fuses to melt when there is really no trouble elsewhere on the circuit. This may occur when the fuse blocks have too little contact surface at the connection points to properly carry the current, or when the contact surface is not secure, in which case arcing occurs, pitting the surfaces and intensifying poor contact.

The formation of an arc may be understood by the following explanation: The two conducting terminals under ordinary circumstances are brought together before being separated to establish the arc. As soon as this separation commences, the spark which tends to form at any break in a closed circuit vaporizes a portion of the materials of the electrodes, thus establishing a bridge of conducting vapor through which the current flow is maintained. The concentration of energy in a small space produces an intense heat, which vaporizes the electrodes more rapidly. The temperature of this arc, although difficult to determine accurately, is about 3500° C. We may obtain an approximate idea of this heat when we consider that about 500° C. are necessary to make solid bodies glow with light, and that the melting-point of platinum is 1775° C.

As was noted previously, the presence of two leaks on an electrical circuit, creating an electrolytic action and finally a break in a circuit, is attended with the destructive arc. It is equally true that the breaking of any circuit, whether it be by means of a properly proportioned switch, the melting of a fuse, or the breaking of a current-carrying wire, is attended with this arc. Where the numerous blowings of fuses have occurred, the porcelain surface of the fuse block is often covered with a layer of metallic substance, which becomes a partial conductor. Upon the repetition of this blowing, an arc is formed and maintained by this metallic layer; in many cases the porcelain cover is fused and broken.

In other cases, particularly slate switch and distributing boards, the melting and resulting arcing have been known to crack the insulating substance and the various conductors short-circuited. In other cases the short-circuiting of an incandescent lamp has destroyed the sockets or controlling devices beyond repair. The throwing out of sparks from arc lamps and the dropping of hot carbons have been known to

cause fire. Sparks from the commutator of motors, from the short-circuiting of flexible cords and of fixture wires, from the short-circuiting of cables in conduits and in manholes, igniting accumulated gases; from short-circuits in sockets, attachment plugs, receptacles, switches, and various other devices have been known to cause fire.

Overheating of wires, of motors, dynamos, and switchboards from overloads; overheating of starting boxes; overheating of theater dimmers and regulating boxes from overload; overheating of improperly made joints, which may be considered the weakest part of an installation, and may include joints between wires, between wires and lugs, between lugs and bus-bars, or between switch blades and clips; overheating of magnet coils or resistances of arc lamps, and innumerable other similar defects have been known to create a fire.

Other sources of fire may be the contact of an incandescent lamp with inflammable material, such as cotton, paper, wood, celluloid goods, etc.; the melting of fuses, the breaking down of insulation, sparking from electrolysis, or short-circuits in places impregnated with inflammable gases, such as benzine, naphtha, ether, hydrogen, gasolene, and many others of explosive nature; also in any class of manufacture where vegetable material is distributed through the atmosphere in the form of dust, extra precautions are absolutely necessary, the least flash or arc being sufficient to cause an explosion. While the electric light is the safest light in places of this character, the wires should be placed in iron conduit, there should be a vapor-proof globe over the lamp, and cut-out and switch should be located at a safe distance.

Candy factories, sugar refineries, flour mills, breweries, saw mills, and others of like hazardous nature may be considered in this category; also textile mills, where there is an accumulation of the particles of stock that is carded out, which particles, owing to their extreme lightness, fill the air in the room and, settling, completely cover everything with an inflammable material usually known as "fly," which is a fine dust of vegetable matter. In this condition the dust may be ignited by the blowing of a fuse or similar accident.

It has been contended that electric light stations burn more rapidly than buildings of the same construction, but used for other purposes, and it has been supposed by some that this is due to the saturation of the walls, floors, and its entire structure with electricity. The atmosphere in central stations supplying light or power is impregnated with ozone, the result of electrostatic discharge from belts and

sparking brushes, and intensified by the more favorable conditions of heat and dryness necessary to the proper operation of a station. That ozone adds to the heat and rapidity of a fire once started is evident and is a subject for further investigation.

It is quite apparent that the same state may be created in manufacturing establishments where favorable conditions exist.

Static electricity has been justly considered as a cause of fire. Combustible gases and vegetable dust may become ignited by the spark resulting from the static discharge from belts.

Electrical excitement manifested by sparks and shocks is so common in manufacturing institutions as to cause no comment. In explosions that have occurred in breweries, dyeing establishments, oilcloth works, printing offices, chemical works, distilleries, flour mills, and manufactories of similar character, the cause has been traced to electric sparking or the friction from static electricity.

It will be noted from the remarks made in this paper that electricity is treated as a source of heat and as such is classed as a fire hazard, and it is fair to say that it presents to us a most dangerous and powerful factor in that respect if permitted to be neglected.

That the situation is not worse is due primarily to the fire underwriters, who early realized the importance of restricting indiscriminate methods of construction, in order that the greatest possible immunity from fires may be secured.

With these facts in mind the National Electric Code was compiled and published by the American Institute of Architects, American Institute of Electric Engineers, American Society of Mechanical Engineers, American Street Railway Association, Factory Mutual Fire Insurance Companies, National Association of Fire Engineers, National Board of Fire Underwriters, National Electric Light Association, and the Underwriters' National Electric Association, a compilation most worthy of the honorable and learned bodies referred to. It provides for almost all emergencies, yet circumstances may and do arise where, from a possible misinterpretation or the unusual conditions present, the code does not seem to apply.

In applying the code it is very evident that care must be taken in the proper discrimination of the hazard and to apply that electrical system which will be less apt to enhance the hazard.

A system which would be comparatively safe to introduce in a department store would fail and break down in breweries, dye-houses, bath-houses, and places of similar character, due to dampness; and

in chemical works, starch and sugar works, textile mills, paper mills, gunpowder works, fur tanneries, coal mines, and flour mills, due to danger of ignition or explosion of the dust by electrical sparking.

Extra precautions should be taken in regard to the use of rubber-covered wire in warm rooms, such as engine and boiler rooms, hot rooms in bath-houses, and in drying-rooms. The same precaution should be taken in regard to the use of any wire, other than rubber-covered, in damp places. Thus, it will be seen that, as conditions vary, one quality of insulation would be advisable in one location and would be absolutely unsatisfactory in another location.

Generators, motors, switchboards, resistance boxes, and equalizers would be unsafely placed if located in damp rooms. Transformers would be dangerously placed if inside buildings where the oil or smoke from the burning out of the coils or the boiling over of the oil could do harm.

It may be correctly judged that, in the installing of electric wiring supplying incandescent or arc lamps, motors, heaters, or other apparatus, extreme care must be taken to avoid, wherever possible, gas-pipes, water-pipes, the space under the bathrooms and water tanks, and general metallic construction, including metal awnings, metal ceilings, iron beams, cornices, awning frames, and signs.

The introducing of various auxiliary devices for varying the candle-power of lamps, lamps in series with bell and telephone systems, and connected to lighting systems, and other similar makeshifts, are in the wrong direction, increasing the fire hazard, not necessarily because of faulty constructions, but because their constant manipulation is in the hands of those less informed or absolutely ignorant of the danger involved. The dangers of poor joints have been discussed, and I can but suggest a remedy, and that is, The only precaution against poor joints lies in the prevention of them.

The secret of long-distance transmission lies in the successful employment of very high voltages, and, regardless of the character of the current employed, the difficulties of insulation confront us. It is important that the line as a whole must be insulated against direct earth connection or short-circuit in underground service, and grounds or short-circuits if the line is an aërial one.

The quality of insulators is another important consideration, owing to surface leakage or puncture. Surface leakage is more to be feared, as it can never be depended upon, being a function of moisture from

rain, wet snow, or fog, and drifting dust, which is difficult, if not impossible, to provide against, and which varies with the location.

High-potential circuits are also objectionable in any location where telephone, telegraph, signal systems, and similar circuits are in proximity to them.

Extra attention must be given to an installation supplied by secondary alternating currents, in order to reduce the hazard and provide for any defects that may result from the breaking down of insulation of primary wires.

Overhead wires should be protected by lightning arresters, the proper distribution of which depends on local conditions.

The more frequent and intense the storms may be in any location, the more lightning arresters should be used. It is important that thoroughly good earth connections shall be obtained and that the wire shall not be subject to mechanical injury.

In order that lightning arresters shall be most effective, the wires leading to the earth should be as straight as possible, avoiding kinks or sharp bends. The best prevention of trouble from dead overhead wires, and the danger from their crossing with telephone, telegraph, or call systems, electric light and power wires, would be their removal.

Trolley systems should be protected by guard wires the entire length of the trolley circuit.

The construction of temporary work for display decorations or general lighting, regardless of the length of time it may be used, should be the same as permanent work. Invariably this kind of construction is rushed in a haphazard way, and, combined with the usual attending flimsy and inflammable decorations, presents a condition not desirable —many times quite dangerous.

The great problem is how to secure safety, and this may be answered: By the proper methods of construction, using only high-grade material.

Evidences of the lack of knowledge on electrical subjects are quite apparent: nails and screws driven into electric light molding, wires in contact with foreign metallic objects, fuses uncovered so that molten metal may fly about among inflammable material, and conductors so overloaded as to be perceptibly hot.

The fire hazard should be always carefully considered in an electrical installation. A system of electric wiring may be ideal from an engineering point of view, and yet as a fire hazard would be most dangerous.

While the operation of electrical apparatus is burdened with many dangers under some conditions, the reverse may be said when the equipment is installed by skilled wiremen guided by experienced engineers and the National Electric Code carefully applied; and it is essential, when alterations or repairs are necessary, that, as a continual safeguard, due notifications be given to the local Board of Fire Underwriters. Under these conditions electricity is as safe as any source of power and the safest source of light known to mankind.

DISCUSSION.

The President.—Does any one wish to ask Mr. Devereux any questions or make any remarks on the subject?

Joseph D. Israel.—I would like to ask Mr. Devereux how the number of fires from electric wires compared with fires from other sources.

Mr. Devereux.—Quite favorably. I had expected to be asked that question, so I came prepared: 1896, 55 electric fires; 1897, 50; 1898, 46; 1899, 76 (13 due to trolley wires on street); 1901, 89 (34 due to trolley wires on street).

L. F. Rondinella.—In what territory?

Mr. Devereux.—Philadelphia. There are about sixteen thousand insured buildings that are wired.

Mr. Israel.—In your notation of electric wires, do you include everything—trolley, telephone, and telegraph?

Mr. Devereux.—Yes, everything. In the majority of those cases it was due to overhead wires, current jumping over lightning arresters and other safety devices.

Carl Hering.—It seems to me that we ought to take into consideration, in connection with those statistics, that although the number of fires has remained about the same annually (approximately 55), yet the number of electric installations has increased very greatly; so that although the actual number has not diminished much, yet the relative number has diminished greatly.

Mr. Devereux.—That is right. Of course, the type of work is increasing very much. Had we as many buildings wired, say twenty years ago, as we have now, there would have been a great many more fires. In those days we used wooden cut-outs, etc. Of course, all that class of material has disappeared. There are a great many places in which electric light is now used where it would be impossible to use any other method of illumination.

Francis Schumann.—Do the insurance companies inspect the wiring of buildings that they insure during construction?

Mr. D&vereux.—Yes. From the time it starts to the time the current is introduced.

Mr. Schumann.—During the course of construction?

Mr. Devereux.—Yes.

Mr. Hering.—Are you having any particular trouble with 250-volt lighting systems?

Mr. Devereux.—No; it is coming more and more into use.

Mr. Hering.—Has no one ever raised any objections?

Mr. Devereux.—Not the slightest. The only complaint I have heard has been that the life of the lamp is too short; otherwise there is not the slightest trouble. There is no possible objection to it. I suppose it will be only a short time when we will be running 500.

Mr. Israel.—That objection to the life of the lamp I think will be removed.

Mr. Devereux.—There is no question about that.

David Halstead.—Is it the recommendation of the Board of Fire Underwriters that all circuits should be carried to as near a fire-proof location as possible instead of having fuses controlling a certain number of lights distributed throughout the building?

Mr. Devereux.—Not only from the Underwriters', but from an engineering standpoint, it should be put in a convenient location, easy of access.

Mr. Hering.—The lights of the recent Buffalo Exposition were run all the time on twenty-two thousand volts, and I do not think they went out more than once or twice.

THE LATEST AND BEST VALUE OF THE MECHANICAL EQUIVALENT OF HEAT.

CARL HERING.

October 18, 1902.

In recalculating some tables recently, the writer required, among other fundamental constants, the latest and best value of the mechanical equivalent of heat. An extended and very thorough search was therefore made in the literature on this subject. The final results were as follows:

The best and most authoritative summaries of the numerous experimental determinations of this constant are unquestionably those contained in two reports to the International Physical Congress of 1900, which met in Paris (Rapports; Congrès Internationale de Physique, 1900, tome I; see chiefly pp. 204 and 226). One of these is on the mechanical equivalent of heat, by Prof. J. S. Ames, of Johns Hopkins University, and the other on the specific heat of water, by Prof. E. H. Griffiths, of Cambridge, England. The specific heat of water and the mechanical equivalent of heat are the same constant in different terms, the former being merely the value of the latter in absolute units.

These two summaries are authoritative and to some extent official, as they are in the form of reports to an international congress. That congress took no action toward adopting any definite value; but a value approximating much more closely to the most probable one than the one in general use does is easily obtained from these reports.

Griffiths, in his report, after a careful comparison of the best determinations, recommends the number 4.187 joules for what is usually termed the specific heat of 1 gram of water raised from 15° to 16° C., measured on the hydrogen scale of the International Bureau. The probable error is less than 1 in 2000. This change in temperature is to be considered the same as the mean value between 1° and 100° C. This value, 4.187, agrees with the one recommended in the report of Ames.

Taking for the value of gravity at sea-level and at 45° latitude, as 9.805966 meters, a standard value given by Helmert and used by our

Coast Survey, the value of the mechanical equivalent reduces to 426.985 kilogrammeters. Some recent, very carefully made researches by Barnes, which were not finished in time to be included in Griffiths' report, give the value 426.6. The allowable error in Griffiths' value affects the fourth figure, and it is therefore hardly justified to retain more than four figures, but in view of Barnes' more recent determination, it would probably be more correct to abbreviate Griffiths' value to 426.9 instead of 427.0.

This value 426.9 kilogrammeters per kilogram, centigrade heat unit, corresponds to 778.1 foot-pounds per pound, Fahrenheit heat unit, which two values may, it seems, be accepted as the best determinations known to-day.

SOME FEATURES OF THE GUAYAQUIL AND QUITO RAILWAY, ECUADOR.

WILLIAM D. BEATTY.

Read November 1, 1902.

Ecuador lies on the west coast of South America, just south of Colombia, and, as its name implies, directly under the equator. The principal seaport is Guayaquil, lying about two degrees ten minutes south of the equator, on the Guayas River, about forty miles from the Pacific Ocean. The capital is Quito, situated 300 miles in the interior, on the great plateau of the Andes, at an elevation of 9000 or 10,000 feet, and almost directly under the equator. The population consists of Spaniards, Indians, and a mixed race known as peons. The Spaniards are the ruling class, but by far the most numerous are the peons, who do all the manual labor of the country and are extremely poor and ignorant. Spanish is the national language, but many of the Indians and peons speak only the Indian dialect. The eastern slope of the mountains is inhabited entirely by Indian tribes, about whom little is known.

In Ecuador the Andes lie quite close to the ocean, running in a general north-and-south direction in two great parallel ranges, with a broad plateau about fifty miles wide between them and connected by numerous cross ranges. Forty or fifty years ago, Garcia Moreno, then President of the republic, had a wagon road built on this plateau, fifty feet wide and 200 miles long, extending from Quito, on the north, to Sibambe, on the south. This wagon road, locally known as the Carretera, is a remarkably well built road for that part of the world, with substantial brick or stone arches over the ravines, and paved on the hills; but there is no connection between it and the coast, except two narrow mule trails, which, in the wet season, are almost impassable. Therefore, travelers from the seaport to the capital have the choice, first, of going by boat to Babahoyo, thence on muleback through Guabanda and over the pass at Panza, probably 14,000 to 15,000 feet high, skirting the side of Chimborazo and meeting the Carretera at Chuquipoquia; or, second, by train to Chimbo, thence by mule along the Chimbo River and through Pallatanga and Pangor,

rising 13,000 feet at Navez Cruz, and meeting the Carretera at Cajabamba.

The first trail is fairly wide, but the pass at Panza is very steep, always bad, and in the wet season impassable. The other trail is narrow and dangerous, especially in wet weather. There is also a trail from Sibambe to Chimbo, but it is so bad that it is seldom used.

Between 1871 and 1880 a railroad was built by Mr. Henry McClellan, an American, from Yaguachi to Chimbo, and cargoes carried by boat between Guayaquil and Yaguachi. In 1885 a contract was made

Fig. 1.—Temporary Trestle Bridge 19 and Suspension Foot Bridge.

with Mr. Marcus J. Kelly, for the extension of the railroad from Chimbo to Sibambe; and in 1887, another contract with him to build from Yaguachi to Duran, nearly opposite Guayaquil. This latter connection was made, and some construction done on the line to Sibambe, but work was finally abandoned on that section, and in 1892 the government took possession of the constructed road from Chimbo to Duran.

In 1896, during the presidency of General Eloy Alfaro, surveys for the government were made from Chimbo to Sibambe by Mr. J.

B. S. Mueller, and in 1897 a contract was made with Mr. Archer Harman, of New York, to build a line from Chimbo to Quito. The following year, this contract having been confirmed by Congress, an engineer corps was placed in the field and, under the direction of Col. W. F. Shunk, ran a preliminary line to Quito. In June, 1899, the final location was begun, and in August of the same year construction started.

Both the Kelly and the Mueller lines were limited to 3 per cent. maximum grades, and attempted to develop a location along the slopes

Fig. 2.—Temporary Trestle Bridge 22.

of the western Cordilleras by a system of loops, eventually reaching the Carretera at Sibambe. The Shunk line followed approximately the old Kelly location, and in March, 1900, had eight kilometers of track laid, and probably eight more under construction, but the tremendous rainfall of the winter of 1899–1900 caused such a succession of slides and washouts on the new line that the engineers became convinced that it was impracticable to build a permanent safe road on this location, under the conditions imposed by the contract, and this line was therefore abandoned.

After examining all other available routes, it became evident that the only feasible location for a railroad over the Andes in this locality was through the valley of the Chan Chan River. But, as the average fall of this river is greater than the allowed maximum gradient on the old location, a concession was asked from the government and finally obtained, to increase the maximum gradient to 5.5 per cent., compensated for curvature, and in May, 1900, work was started on the Chan Chan route.

The old line from Duran to Chimbo had a gage of three feet, laid

FIG. 3.—BRIDGE 22, EIGHTH CROSSING OF CHAN CHAN RIVER.

with various weights of rail, and in 1897 was in very bad condition, with the ties, bridges, and culverts, and also the equipment, going to pieces. The concession to Mr. Harman included changing the gage of this road to forty-two inches, to conform to the proposed new line, building new piers and stations at Duran and Guayaquil, and placing the whole system in good condition. The gage has been changed, new piers and stations have been erected, and the roadbed practically rebuilt with new ties and fifty-five-pound rail, the equipment overhauled and largely augmented, the shop efficiency enormously

increased, and the whole system reorganized. This road, fifty-six miles long, and another, of six miles, near the coast to the south, were the only railroads in the country at the beginning of the present century.

The Chan Chan line, as finally located, leaves the old line at Bucay Junction, two miles west of Chimbo, crosses the Chimbo River and the divide between the two valleys, and reaches the Chan Chan four miles beyond. From this point it follows the Chan Chan Valley for twenty-four miles, crossing and recrossing the river until it reaches

Fig. 4.—Alinement at Bridge 28.

the Pistichi Nose, where the river divides. Here the line, after crossing the northern branch, the Alausi, extends on a double switchback along the face of the Pistichi Nose to the Alausi basin, then on a double loop through the town of Alausi to the summit of the pass, and from there to the town of Guamote, where it reaches the Carretera, fifty-eight miles from Bucay. The maximum curve is twenty-nine degrees and the maximum gradient 5.5 per cent., compensated at the rate of 0.03 per cent. per degree of curve.

For the first eight miles the grades are easy—not over 3 per cent.

—and the work generally light. The heavy grade begins nine miles from Bucay, and thereafter, except for one short stretch of 700 feet, it is a steady climb up the mountains for thirty-two miles without a break, the ruling grades running from 4 to 5.5 per cent. There are twenty-six crossings of the Chan Chan alone, of which twelve are truss bridges, the remainder plate girders. There are, besides, nineteen smaller girder bridges and numerous small structures.

The bridges are all steel, designed according to Theodore Cooper's specifications, and the masonry either stone, laid in Portland cement,

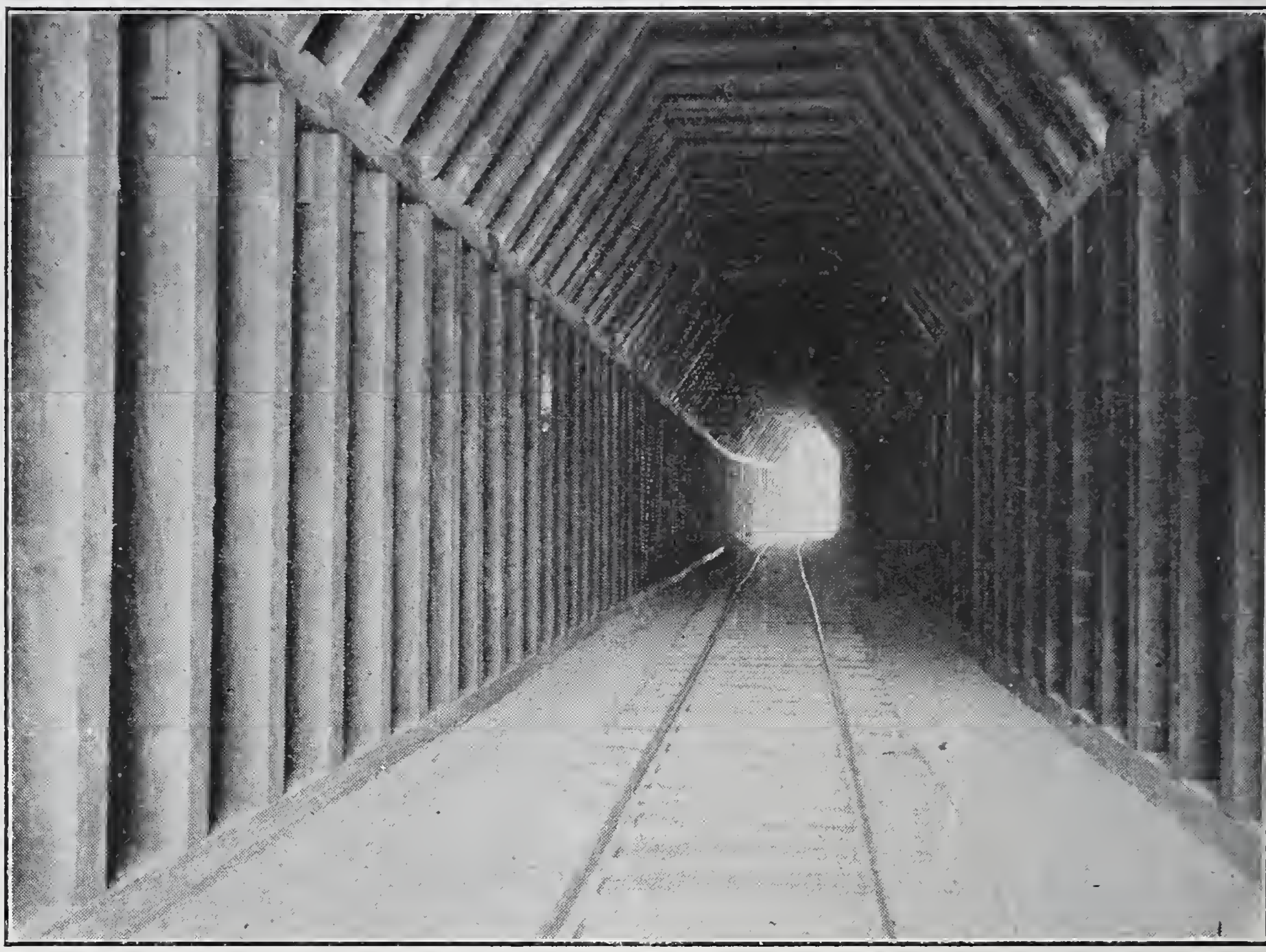


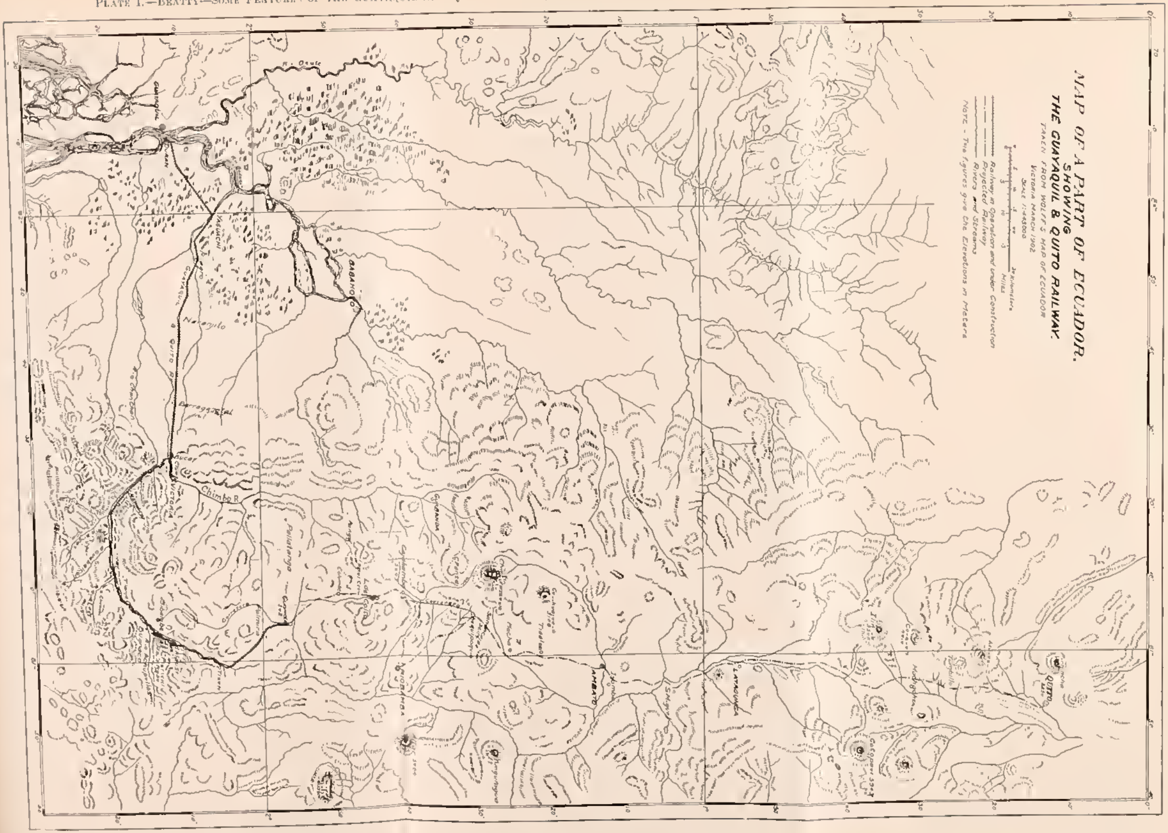
Fig. 5.—Timber-lined Tunnel with Temporary Track.

or concrete in the proportion of 1 : 3 : 5, with coping blocks either of stone or concrete in the proportion of 1 : 2 : 4. In spite of occasional difficulty with foundations, and a very poor class of labor, none of this masonry has shown any signs of settlement.

There are only three short tunnels on the entire line, the longest one being 256 feet. This one was lined with timber; the others were cut through solid rock.

The critical point of the Chan Chan line was at Pistichi Nose, where the river divides. The branch to the north, the Alausi, has a 10

PLATE I.—BEATTY—SOME FEATURES OF THE GUAYAQUIL AND QUITO RAILWAY, ECUADOR.—*Proceedings of The Engineers' Club of Philadelphia*, Vol. xx, No. 1 (January, 1903).



per cent. fall; the other, to the east, the Achupallas, has an easier fall, but involved such an expensive crossing of the saddle of the mountain as to be prohibitive. As the valley was too narrow for a loop development, a switchback was necessary either toward Sibambe on the mountain to the north, thus striking the Carretera directly, or along the face of the Pistichi Nose on the east, making enough elevation, with a further development in the Alausi basin six miles beyond, to carry the grade above the river elevation.

The mountain on the Sibambe side rises very abruptly, and to run

Fig. 6.—Pistichi Nose, Showing Switchback.

a switchback there would have been a long and expensive operation, and it is doubtful if a railroad could have been held there at all in the wet season. Therefore, a double switchback was cut through solid rock along the face of Pistichi Nose, for a distance of 3700 feet back from river spur to hill spur, then forward again on the high grade. This line is now open and a regular train service established. Directly above the low-grade switch, the high grade is 266 feet above the low grade. This gain in elevation carried the grade to the Alausi basin, where the river elevation is again reached. But the valley

widens out here, and a long double loop was constructed, making a gain in elevation of 478 feet. The upper end of this loop reaches the town of Alausi, the only place of any importance, and almost the only settlement between Chimbo and the plateau.

Above the switchback there are two plate girder bridges crossing the Alausi River, two over ravines, one viaduct 340 feet long and 59 feet high, two truss bridges over ravines, and, four miles above Alausi, at the third crossing of the river, a second viaduct 373 feet long and 122 feet high. The country at this second viaduct is of volcanic

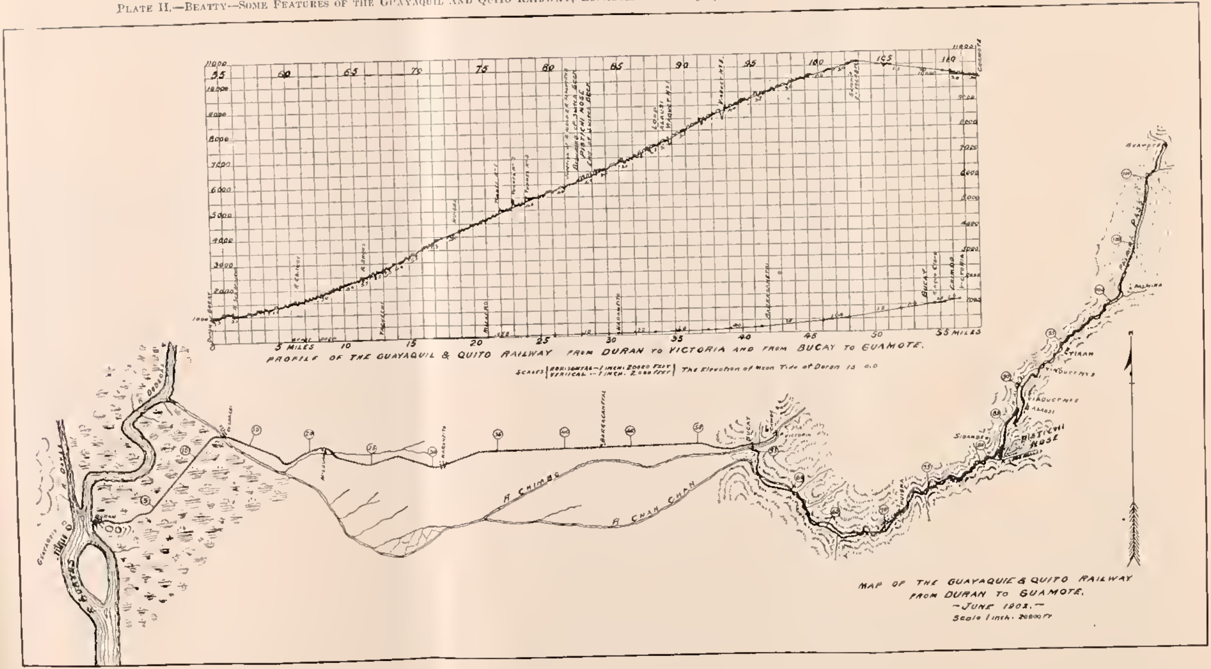
Fig. 7.—Camp near Alausi.

origin, with quantities of loose material on the side slopes, and great masses of talus at the foot of the cliffs, intermingled with enormous boulders, and the problem of finding foundations for the viaduct, as well as a safe roadbed, at first looked rather serious.

The alternative propositions were, first, to cross the river lower down, involving several thousand feet of viaduct and a long tunnel; or, second, as a last resort, to switchback toward Sibambe.

Both these propositions being very expensive, and the original location, after being cleared, looking more favorable, the line was

PLATE II.—BEATTY—SOME FEATURES OF THE GUAYAQUIL AND QUITO RAILWAY, ECUADOR.—*Proceedings of The Engineers' Club of Philadelphia*, Vol. XX, No. 1 (January, 1903).



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finally built as located. The side slopes have held through one wet season as well as could be expected, and good foundations for the viaduct obtained, while the country beyond, all the way to Guamote, presents no difficulties whatever.

The heavy grade continues two miles beyond the viaduct, then drops to 4 per cent., then to 3, until, forty-nine miles from Bucay, the summit of the pass is reached at an elevation of 10,648 feet, making an average grade from Bucay to the summit of nearly 3.8 per cent.

Fig. 8.—Site of Viaduct 2.

From this point there is an easy descending grade of 1.5 to 2 per cent. to Guamote and the Carretera.

There are numerous small crossings of the Alausi, but as the river above the second viaduct has a very moderate fall, with little scour, all bridges are built of timber. In many places, instead of bridging, the channel of the river is diverted.

From Guamote north, the country is partly located, but no construction has been done. The grades are limited to 3 per cent. maximum, and the curvature will be much easier. Wherever possible, the Carretera will be used; but as the latter is very hilly, with some

of the grades running up to 12 or 15 per cent., it is possible that most of the roadbed will be new. The line as projected will pass through Columbe and Cajabamba, making a detour to reach Riobamba, then over the pass at Sanancajas, probably 12,000 feet above sea-level, down to Ambato and on through Latacunga and Machache to Quito.

This road from Riobamba to Quito is a most remarkable sight. On either side are towering mountains, while here and there snow-covered peaks rise above the range level, with their summits lost in the clouds. From Riobamba can be seen the volcano of Tunguragua

Fig. 9.—Summit, Elevation 10,648 Feet.

and the twin peaks of Altar, while 4000 or 5000 feet below the snow line the Carretera winds along the side of Chimborazo, one of the highest peaks on the western continent. Farther north are Iliniza and Corozon on the west, and Pichincha, at whose base lies Quito, while on the east is Cotopaxi, the results of whose last eruption can be plainly seen, even along the Carretera.

Along the road itself, especially on a market day, is moving a continuous stream of peons with their pack animals. Everything from tin cans to household furniture is carried on the backs of either

the peons or mules, burros, oxen, or occasionally llamas; and the various groups, with their gay-colored ponchos, driving their cargoes to market, make a continually interesting picture, while occasionally a horseman with jingling spurs, or, two or three times a week, a coach, with its four, five, or six mules on a dead gallop, dashes into the crowd, scattering the cargoes right and left. Pianos and extra heavy freight are carried bodily on heavy poles slung on the backs of forty or fifty men, who move all day long at a steady jog trot, resting for the night wherever they happen to be.

Fig. 10.—Entrance to Quito.

Practically all material for construction purposes was imported from the United States. Some native timber has been used for ties and temporary trestles, but by far the greater part of the timber, as well as all bridge steel, rails, track material, cement and construction material, engines, cars, and other equipment, was imported.

As there were no roads in the Chan Chan Valley, a trail for transporting supplies and men was first built and extended from time to time. The rivers were crossed by stringer bridges, or, where the waterway was too great for them, by suspension bridges made from

telegraph wire. As the railroad was opened for business these bridges were destroyed, and the trail in that section abandoned. This trail, although bad in places and very narrow, being often merely a shelf cut along the side of the mountain, was by far the best trail to the capital, and was used quite largely by the natives, although only intended for construction purposes.

Headquarters were established on a plateau half a mile above Chimbo, and substantial frame houses, with running water and a sewerage system, constructed. From this point a line of engineers' camps was organized, extending as far as Guamote, with an additional party ahead on preliminary work. The first four of these camps were built of bamboo cane; in the remainder the men lived in tents. At one time there were thirteen engineers' camps in operation simultaneously, but, as the track advanced, the lower camps were abandoned. The contractors and subcontractors, of course, had their own camps and outfits. Most of the supplies for all camps had to be packed from headquarters.

The natives could not be induced to work on the lower part of the line, so 3000 laborers were imported from Jamaica and they built nearly all of the road below the Nose. The natives were quite willing to work in the upper country, and that part of the line was nearly all built by them.

As there was no way of transporting bridge material ahead of the track, a large force was organized, building temporary timber trestles over the river in the dry season, the sticks being dragged along the partly finished grade by ox teams. As soon as the condition of the grading permitted, track was laid on temporary ties, construction materials brought by train, and the masonry walls built. A bridge gang followed, erecting the steel superstructure.

The Chan Chan, as well as the smaller streams in the lower country, has a tremendous scouring effect, and in the wet season it is almost impossible to maintain a trestle in the river bed. All the truss spans were safely erected before the river became dangerous, but some of the smaller crossings were washed out, causing considerable delay. In some of these temporary trestles the bents were driven with a pile driver, but they did not seem to stand any better than the others.

The retaining walls on the switchback were built ahead of the track. Cement and sand were carried to the end of track, then packed to the site on mules. Even the water had to be packed from the river at the foot to the upper grade.

The side slopes were generally taken out at ¼ to 1. In some places they were flattened to ½ or ¾ to 1, but generally the mountains rise so abruptly that any flatter slope enormously increases the cost. With a few exceptions these cuts have stood very well.

The track is forty-two inches gage, laid with fifty-five-pound rail, on rail plates, with inside guard rails on the heavy curves. Ties are six by eight by seventy-eight inches long, either of native hard wood or of California red wood, laid on stone ballast.

Building stone is abundant; sand of a fair quality can be obtained, but timber, while plentiful in the low country, gets very scarce along the upper Chan Chan, and disappears entirely along the Alausi.

On the old Duran-Chimbo line, and also on the first ten miles of the new line, the labor required to keep the right of way cleared was a heavy expense. In that tropical country vegetation grows so fast that it was necessary to keep a large force constantly employed cutting weeds. To avoid this, the railroad company is now using a patent process, by which a fluid composition is scattered along the track from a moving tank car, thus, after two or three applications, effectually killing the vegetation wherever it reaches. This method is also used on the Panama Railroad.

The equipment consist of eight forty-four-ton Baldwin engines (exclusive of weight on tenders), two Shay geared engines, 320 freight cars, and eight passenger coaches, all supplied with Westinghouse automatic air brakes. On the heavy grades the speed, of course, is slow and the trains light, but a regular passenger and freight train service is now in successful operation between Duran and Alausi, this section including nearly all the heavy grade.

Although the progress of the work has, at times, seemed slow, the difficulties of building a railroad in a country like Ecuador are very great. Besides the natural obstacles to be overcome, the ignorance and cupidity of the natives, the poor quality of the labor, the scarcity of the commonest materials for construction, poor food, a trying climate, absolute lack of sanitary arrangements, continual harassing by discharged employees, distance from supplies, strikes and riots among the laborers, and always and ever the difficulty of transportation make it an undertaking requiring great judgment, iron nerves, and infinite tact and patience in the management. In spite of the large number of men employed,—probably 10,000 at one time,—the very dangerous character of the work on mountain slopes liable to slip, and the difficulty of keeping so many men in a wild country

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from dissipation and rioting, the mortality has been remarkably light and the fatal accidents very few. This is in marked contrast to the history of the Arroya Railroad in Peru, where the conditions were similar in many respects.

This railroad should be, when completed, remarkable for its varied scenery. Starting in the swamps at Duran, it passes through magnificent groves of cocoa and palm and enormous tropical forests, with all the fruits common to tropical countries. Then, ascending into the higher country, the forests gradually grow less dense, until they disappear altogether, and the bald faces of the mountains stand out in sharp relief, rising one above the other, until, finally, crossing the sand plains of the pass, the Carretera is reached, where are grown wheat and barley, apples and strawberries, and most of the products of the temperate zone; then on between the mighty ranges of the Andes to Quito, uniting at last the seaport and the capital, and, perhaps, forging a link in the great intercontinental railway of the future.

DISCUSSION.

The President.—The subject of this paper is open for discussion. Do any of the members wish to ask any questions?

John C. Trautwine, Jr.—I would like to ask Mr. Beatty to give us an idea of what that solution was that they used to check vegetation.

Mr. Beatty.—It is a patented process. I cannot tell. There's arsenic in it.

A Member.—What are the wages paid to the natives?

Mr. Beatty.—We have paid seventy-five cents a day, which was too much. You can get labor there for about forty cents. The subcontractors bid against each other. It averages from sixty to seventy-five cents a day.

A Member.—Do they furnish board?

Mr. Beatty.—No; the natives don't eat very much. They bring two weeks' provisions on their backs and when that is gone, they go home and another lot must be hired.

A Member.—Where do the foremen come from?

Mr. Beatty.—Mostly from the States.

A Member.—What is paid them?

Mr. Beatty.—There's no special rate for them.

Carl Hering.—What is the nature of the traffic that warrants building such an expensive road?

Mr. Beatty.—It is entirely local business. There is an enormous business carried on between the towns on the plateau and the seaboard, and this railroad is to get that traffic, for one thing, and it is also to be used as a government road for conveying troops.

Mr. Hering.—Is Quito a manufacturing town?

Mr. Beatty.—They manufacture very little. There is a continual traffic all the time along that wagon road. I can't altogether account for it, but it is there. All the supplies have to come from the coast—house supplies and everything of that sort.

Arthur Falkenau.—Is there any mining in that region?

Mr. Beatty.—Not just where we were located. It is more to the south. We have found some coal, however, and there is a sulphur mine near the viaduct site.

Mr. Hering.—Are the rivers at all available for water-power?

Mr. Beatty.—Yes, I think they are. We examined into that question at one time. It has not been adopted, but I think it can be. The Chan Chan has a steady flow even in the dry season.

Mr. Hering.—Was the project considered to build an electric road?

Mr. Beatty.—It has been thought of, but not adopted. The question has been gone into. It may eventually be changed to an electric road. Just at present they decided to go on with the original idea.

The President.—Has the cost per mile of that railroad ever been computed?

Mr. Beatty.—The figures have not been given out. In the section round the Pistichi Nose it was very expensive, the excavation running one hundred thousand yards of solid rock to the mile, without counting retaining walls.

A NEW METHOD OF TESTING WIRE.*

ARTHUR FALKENAU.

Read November 1, 1902.

The object of this paper is not merely to present an argument in favor of the methods of testing wire herein advocated, but to promote discussion thereon, as well as on the present method of use and manufacture of wire rope with a view of ultimately arriving at more satisfactory results. It is quite recently that manufacturers have concluded to advise the use of larger drums and sheaves for soft steel or iron rope than for cast or plow steel rope. This is evidently a move in the right direction, but it is to be presumed that they are still somewhat in the dark, as no two of them seem to agree exactly as to what these diameters should be.

Plow steel rope is, or should be, the best for any purpose, this quality commanding a much higher price than any of the other grades of hoisting rope. By referring to manufacturers' lists it will be noted that, with one or two exceptions, no larger sheaves are now specified for plow steel than for cast or extra strong steel rope.

The term "plow steel" refers to wire of a tensile strength of 200,000 pounds per square inch, and even higher. The wire selected for all sizes of rope from 2½ inches to the smallest diameter should be uniformly graded in strength from 200,000 to 275,000 pounds per square inch approximately.

It does not follow that wire of this high strength will necessarily show a reduced number of bends received in testing; on the contrary, if the wire is made from good quality of stock and properly treated they should be increased.

It is a fact that the most serious wear on wire rope is due to the constant bending when under strain over sheave wheels or drums, and this deterioration increases proportionately with greater speed. Therefore, to make a quality of rope that will handle the greatest possible tonnage, wire must be selected that will stand the highest

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*Mr. Falkenau, in presenting the subject "A New Method of Testing Wire," exhibited the Moore testing apparatus, and explained the manner of its use.

number of bends of not less than 90 degrees under a load uniformly proportionate to its ultimate strength with each test specimen. Of course, this static load under which the bending is made must be below the elastic limit, and if this plan is followed it will not be necessary

Fig. 1.

to consider either the torsional or elongation test simply because wire rope is not subjected to either of these strains when installed. It must be admitted that, if in a rope by torsion or elongation the elastic limit is passed, the rope has been ruined. It has been the practice to apply torsion and elongation tests to the wire. As both

these tests are carried at once beyond the yield point, the relative deductions are not very reliable and it seems a waste of time to continue the torsion and elongation tests. To facilitate the explanation that follows of the testing machine for wire, herewith exhibited, it is considered necessary to refer to the old and in some cases the present method of testing wire for rope.

After the coil of wire is found true to size and otherwise passes inspection, each end is or should be tested to ascertain the ultimate strength. If this result is in accordance with requirements, the next operation is the bending test. This is accomplished by clamping the test-piece between jaws and bending the wire through an arc of,

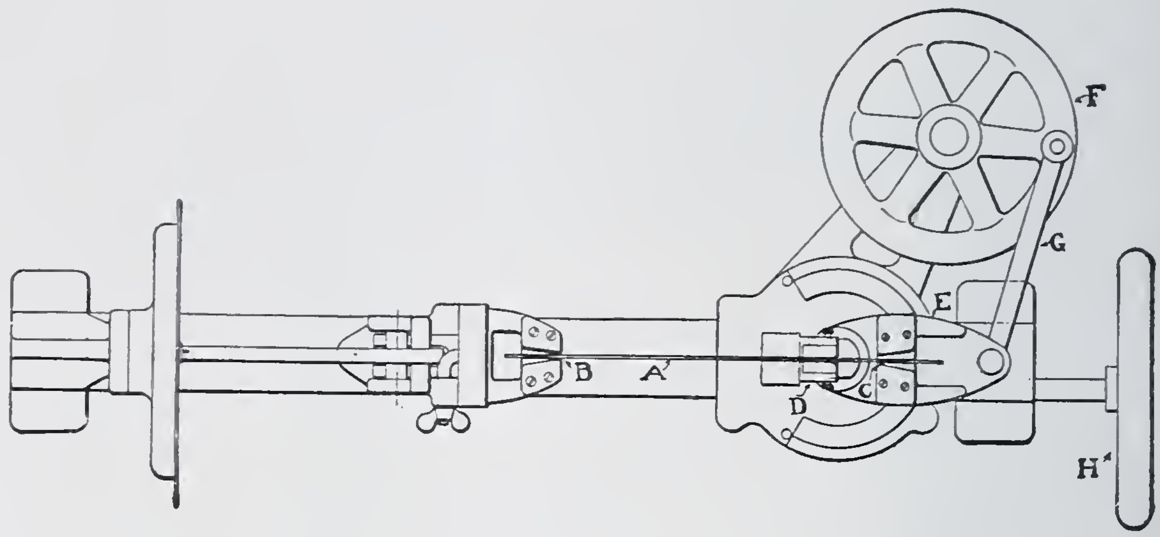

Fig. 2.

The specimen of wire A is introduced into the grips at B and C and passes between the hardened steel blocks at D. For a tensile test, turn the hand-wheel H, which pulls the head straight out and the scale will record the load. For bending test, apply the desired initial load by means of the hand-wheel H, then rotate the hand-wheel F, which will swing the arm E by means of connecting rod G, bending it about the hardened steel blocks at D.

say, 180 degrees, using jaws with a radius corresponding to the diameter of wire in each case. If the number of bends falls below that which is called for by a table of past records, then this coil is rejected.

Until the machine (Fig. 1) designed to apply this test under strain was perfected, there was no means of knowing whether tests made in the above manner gave reliable results or not; experience, however, indicated that, in applying the old form of bending test, on general principles the wire, if below normal, should be rejected. To show the fallacy of this idea it is only necessary to say that it is possible to produce wire made from low carbon steel or even double-worked refined iron, from which a test-piece of a given diameter of wire will

show more bends under the old system than the best plow steel stock. If, however, the bend test is applied under exactly the same conditions and subjecting each piece to a load of, say, one-fourth its ultimate strength, then the plow steel stock will at once prove its superiority for rope.

Considering the matter of testing wire in the new machine before referred to, the tensile strength test is required to determine whether the whole number of wires to be used in the rope will have a combined strength equal to requirements, also to enable the operator to ascertain what load each wire should be submitted to when the bend test is made. Uniform stock, whether cast, extra strong, or plow steel, will show a variation in making the bending test in the new way of perhaps 5 per cent., and if the same stock is tested over jaws of the same radii without strain, wire will be passed that ought to be rejected and *vice versâ*.

This machine has been designed not only with a view of saving labor in the physical laboratory by demonstrating that there is no necessity for either the torsional or elongation test, but as a reliable means of subjecting wire for rope to tests that coincide with the conditions of its use. The first machine perfected has been in constant use for the past two years, during which time it has demonstrated its superiority as a means of determining the quality of wire when the principal requirements are tensile strength and ductility.

It was not deemed advisable to consume time by submitting records of tests, but rather to show the machine in actual operation, it being noted that tables are prepared to go with the machine, one of which is presented showing how one piece of rope is compared with another, by which tests it is easily determined which of the two ropes will handle the greatest tonnage.

ABSTRACT OF MINUTES OF THE CLUB.

Regular Meeting, October 4, 1902.—President Hartley in the chair. Sixty-six members and visitors present.

Mr. John C. Trautwine, Jr., presented the subject of "Fire Mains." A discussion followed, which was participated in by Messrs. Charles G. Darrach, E. M. Nichols, H. Wilmerding, Francis Schumann, Carl Hering, Thos. C. McBride, John E. Codman, and others.

Regular Meeting, October 18, 1902.—President Hartley in the chair. Sixty-one members and nineteen visitors present.

Mr. Washington Devereux presented a paper upon "Some Electrical Fire Hazards," which was discussed by Messrs. Joseph D. Israel, Carl Hering, Francis Head, David Halstead, and others.

Mr. Carl Hering made a few remarks on "The Latest and Best Value of the Mechanical Equivalent of Heat" and on "Recent Progress in Single-phase Traction."

Regular Meeting, November 1, 1902.—President Hartley in the chair. Sixty-five members and ten visitors present.

Announcement was made of a proposed tour of inspection of the Roxboro Filtration Plant, on the afternoon of November 15th.

Mr. Wm. D. Beatty read a paper entitled "Some Features of the Guayaquil and Quito Railway, Ecuador, S. A." The subject was discussed by Messrs. John C. Trautwine, Jr., Carl Hering, and others.

A recently constructed machine for testing wire was exhibited by Mr. Arthur Falkenau.

Business Meeting, November 15, 1902.—President Hartley in the chair. Fifty-five members and fifteen visitors present.

Announcement was made that the twenty-fifth anniversary of the organization of the Club would be celebrated by a banquet at the Union League on December 6th.

Mr. John E. Codman read a paper entitled "Philadelphia High-pressure Fire Service," which was discussed by Messrs. John C. Trautwine, Jr., James Christie, Edwin F. Smith, Henry Quimby, and others.

The Tellers reported the election of Messrs. S. Cameron Corson, Paul W. England, W. Herman Greul, Carl Horix, and Henry Szlapka to active membership, and Mr. Wallace R. Lee to junior membership.

Business Meeting, December 9, 1902.—President Hartley in the chair. Twenty members present.

Nominations for officers were presented as follows.

For President,	*Proposed by*	*Seconded by*
EDWIN F. SMITH.	James Christie.	L. Y. Schermerhorn.
For Vice-President,		
HORATIO A. FOSTER.	Thos. C. McBride.	Charles Piez.
For Secretary,		
J. O. CLARKE.	Thos. C. McBride.	W. B. Riegner.
L. F. RONDINELLA.	Thos. G. Janvier.	Allen J. Fuller.
For Treasurer,		
GEO. T. GWILLIAM.	James M. Dodge.	L. Y. Schermerhorn.
For Directors,		
JAMES B. BONNER.	Geo. T. Gwilliam.	Philip H. Johnson.
DANIEL A. HEGARTY.	Wm. C. L. Eglin.	Rich'd L. Humphrey.
GEO. NEVILLE LEIPER.	Minford Levis.	S. G. Comfort.
JNO. T. LOOMIS.	Geo. T. Gwilliam.	Washington Devereux.

The President named the Committee on Nominations, as follows: James Christie (Chairman), Silas G. Comfort, Wm. C. L. Eglin, and Wm. Copeland Furber.

The chair ruled that in accordance with the By-Laws there should be but one proposer and one seconder published for each candidate.

BUSINESS MEETING, December 20, 1902.—President Hartley in the chair. Fifty-seven members and one visitor present.

Mr. Henry S. Spackman presented a paper upon "The Manufacture of Portland Cement from Marl and Clay." The subject was discussed by Messrs. Herbert T. Grantham, James Christie, Eugene M. Nichols, Richard L. Humphrey, and others.

The Tellers reported the election of Mr. F. C. Andrews to active membership, Messrs. W. Jordan, Jr., Harold T. Moore, and Charles J. Pfeiffer to junior membership, and Mr. A. H. Bromley, Jr., to associate membership.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Regular Meeting, October 18th, postponed until October 22d.

Adjourned Meeting, October 22, 1902.—Present: President Hartley, Vice-President Comfort, Directors Foster, Riegner, Hewitt, and McBride, the Secretary, and the Treasurer.

The Treasurer's report showed:

Balance, August 31, 1902,	$1641.79
September receipts,	265.36
	$1907.15
September disbursements,	372.79
Balance, September 30, 1902,	$1534.36

The resignation of Mr. H. V. B. Osbourn as Regular Teller was presented and accepted with the thanks of the Board for the faithful service he has rendered, and Mr. Washington Devereux was made Chairman of the Committee of Tellers, Mr. William E. Bradley a Regular Teller, and Mr. H. P. Cochrane an Alternate Teller.

The thanks of the Board were extended to Mayor Ashbridge, Directors English and Haddock, Messrs. John W. and Henry Hill, and Mr. D. J. McNichol for the courtesies extended to the Club in connection with the inspection of the Torresdale filtration plant on the 18th instant.

After the report of the preliminary committee appointed to consider the celebration of the Club's twenty-fifth anniversary, it was decided that it should be in the form of a banquet, to be held on December 6th, at the Union League.

Regular Meeting, November 15, 1902.—Present: President Hartley, Vice-President Smith, Directors Foster, Riegner, and McBride, the Secretary, and the Treasurer (later, Vice-President Comfort).

The Treasurer's report showed:

Balance, September 30th,	$1534.36
October receipts,	288.85
	$1823.21
October disbursements,	704.67
Balance,	$1118.54

The Finance Committee reported all bills approved and paid to date.

Upon request of the Publication Committee it was resolved that the Club's stenographer be engaged to report the speeches, etc., at the anniversary meeting at the Union League on December 6th.

Regular Meeting, December 20, 1902.—Present: President Hartley, Vice-Presidents Smith and Comfort, Directors Foster, Riegner, and McBride, the Secretary, and the Treasurer (later also Director Hewitt).

The Treasurer's report showed:

Balance, October 31st,	$1118.54
November receipts,	451.60
	$1570.14
November disbursements,	474.20
Balance,	$1095.94

Resignations were accepted as follows: From active membership, Walter S. Church, L. C. Dilks, Henry Leffmann, E. O. Macferran, Louis R. Shallenberger, and O. M. Weand.

The following were transferred to the active list: Howard M. Ingham, Samuel J. Magarge, Jr., H. W. Nelson, Arthur B. Stitzer, and Frank G. Rowbotham.

ADDITIONS TO GENERAL LIBRARY.

From Emil L. Nuebling, Reading, Pa.

Thirty-seventh Annual Report of Board of Water Commissioners, Reading, Pa., 1901–1902.

From Wm. B. Phillips, Director, University of Texas Mineral Survey, Austin, Texas.

Bulletin No. 4, October, 1902.

From Philip D. Borden, City Engineer, Fall River, Mass.

Report of the Reservoir Commission, Fall River, Mass., 1902.

From Theodore Cooper, New York.

General Specifications for Foundations and Substructures of Highway and Electric Railway Bridges, 1902.

From George S. Webster, Chief Engineer, Bureau of Surveys, Philadelphia.

Annual Report, 1901.

From State Board of Health, Boston, Mass

Thirty-third Annual Report, 1901.

From John C. Trautwine, Jr., and John C. Trautwine, 3d, Philadelphia.

Civil Engineer's Pocket-Book, eighteenth edition, 1902.

From the Parkway Association, Philadelphia.

The Philadelphia Parkway Project, 1902

From C. E. Schermerhorn, Philadelphia.

Architectural Studies. 1902.

From Nova Scotian Institute of Science, Halifax, N. S.

Proceedings, vol. x, part 3.

From University of Pennsylvania.

The Provost's Report for the year ending August 31, 1902.

THE ENGINEERS' CLUB OF PHILADELPHIA,

House, No. 1122 Girard Street,

PHILADELPHIA, PA.

ANNUAL REPORT OF THE BOARD OF DIRECTORS

For the Fiscal Year 1902

JANUARY 7, 1903.

TO THE ENGINEERS' CLUB OF PHILADELPHIA:

In compliance with the requirements of the By-Laws, the Board of Directors offer the following report for the year ending December 31, 1902.

Eighteen regular meetings of the Club were held, at which the maximum attendance was 92, and the average 68. Seven stated and four special meetings of the Board of Directors were held.

Eighteen active, 2 associate, and 15 junior members were elected; 16 active members resigned; 7 active and 2 associate members were dropped from the rolls; 1 associate and 5 junior members were transferred to the active list.

The record of deaths is:

F. H. Bowen, Active Member, died March 5, 1901.

W. Hasell Wilson, Honorary Member, died August 17, 1902.

The membership of the Club on December 31, 1902, as compared with the previous year was as follows:

	1901.			1902.		
Class.	*Resident.*	*Non-Resident.*	*Total.*	*Resident.*	*Non-Resident.*	*Total.*
Honorary	2	6	8	1	6	7
Active	299	120	419	299	120	419
Associate	14	1	15	14		14
Junior	6		6	12	4	16
	321	127	448	326	130	456

The following papers have been presented :

JANUARY 4TH . . . . S. W. Stratton, Director, U. S. Bureau of Standards.
The Relation of the National Bureau of Standards to Engineering and Manufacturing Interests.

JANUARY 18TH . . . . Henry Leffmann.
Address of retiring President, Ancient Metallurgy.

FEBRUARY 1ST . . . . C. H. Ott.
The Improvement of the Channels of the Delaware and Schuylkill Rivers by the City of Philadelphia.

FEBRUARY 15TH . . . . Wm. H. Berry.
Superheated Steam.

MARCH 1ST . . . . . . John Birkinbine, L. Y. Schermerhorn, John E. Codman.
Discharge of Streams. General Discussion.

MARCH 15TH . . . . Wm. Copeland Furber.
The Recent Conflagration at Paterson, N. J.

APRIL 5TH . . . . John Birkinbine.
Changes in the Manufacture of Pig Iron.

APRIL 19TH . . . . James Christie.
Modern Developments in the Production of Open-hearth Steel.

MAY 3D . . . . William Hewitt.
Aërial Cable Transportation.

MAY 17TH . . . . Oscar C. S. Carter.
The Southwest and the Arid District Traversed by the Engineers of the Mexican Boundary Commission.

JUNE 7TH . . . . Jno. Gordon Gray.
Wireless Telegraphy.

SEPTEMBER 20TH . . . . Horatio A. Foster.
Depreciation as Affecting Engineered Structures. Topical Discussion.

OCTOBER 4TH . . . . John C. Trautwine, Jr.
Fire Mains.

OCTOBER 18TH . . . . Washington Devereux.
Some Electrical Fire Hazards.

OCTOBER 18TH . . . . Carl Hering.
Remarks on the Latest and Best Value of the Mechanical Equivalent of Heat, and on Recent Progress in Single-phase Traction.

NOVEMBER 1ST . . . . William D. Beatty.
Some Features of the Guayaquil and Quito Railway, Ecuador.

NOVEMBER 1ST . . . . Arthur Falkenau.
Exhibition of Wire-testing Machine.

NOVEMBER 15TH . . . . John E. Codman.
Philadelphia High-pressure Fire Service.

DECEMBER 6TH.
Celebration of the Twenty-fifth Anniversary of the Club's Organization.

DECEMBER 20TH . . . . Henry S. Spackman.
The Manufacture of Portland Cement from Marl and Clay.

The Information Committee made arrangements for inspection tours to the Torresdale and Roxboro filtration plants, in which members and their friends participated, on October 18th and November 15th, respectively.

One hundred and twenty volumes of periodicals were bound and have been added to the books in the library, although not yet placed in cases for lack of space. Eleven periodicals have been added to the exchange list.

Portières have been purchased and hung at the entrances to the meeting-room and parlor, and three Morris chairs have been added to the parlor furniture.

The substitution of one pane of glass in each sash of the front windows on the first floor is another improvement to the house.

The Keystone Telephone Co. has placed one of its pay 'phones in the hall on the first floor, without expense to the Club.

The furniture and fixtures of the house are in excellent condition.

NET EXPENDITURES FOR 1902.

House	$2172 25
Proceedings	780 23
Library	153 98
Information	148 85
Office	452 92
Salaries	1680 00
	$5388 23

ASSETS, DECEMBER 31, 1902.

Furniture and fixtures, as per appraisement February 17, 1900, with subsequent additions	$1811 22	
Library, as per appraisement February 10, 1900, with subsequent additions	2254 65	
Total furniture and library		$4065 87
U. S. Bond, issue of 1898 (par $500), market value		532 50
On deposit, bearing interest at three per cent.		545 55
On deposit, bearing interest at two per cent. (including $635, dues for 1903)		796 31
		$5940 23

NO LIABILITIES, ALL BILLS HAVING BEEN PAID TO DATE.

The Board desires to express its thanks to the members of the Special Committee of Arrangements having charge of the Twenty-fifth Anniversary Banquet, for the able manner in which they handled the exercises; and furthermore, desires to state that this celebration was without expense to the Club, except for the printing of matter to appear in the Anniversary number of the PROCEEDINGS, which will be issued during the current month.

Respectfully submitted,

HENRY J. HARTLEY, *President.*

L. F. RONDINELLA, *Secretary.*

Report of the Treasurer for the Fiscal Year 1902.

Receipts.

Initiation fees (35) . .	$175 00	
1895 dues	5 00	
1896 dues	5 00	
1901 dues	210 00	
1902 dues	4375 00	
1903 dues	635 00	
		$5405 00
Proceedings :		
Advertisements . .	$327 00	
Sales	77 33	
Reprints	74 75	
		479 08
Interest on deposits		50 64
Interest on investment . . .		15 00
Telephone		9 06
Billiards		21 55
Binding books		2 00
Cigars		2 50
Total receipts		$5984 83
Cash balance, Dec. 31, 1901 .		1224 34
		$7209 17

Expenditures.

Salaries :		
Secretary	$240 00	
Treasurer	60 00	
Clerk	840 00	
Janitor	540 00	
		$1680 00
House :		
Rent	$1100 00	
Coal	104 80	
Gas and electric light	102 78	
Ice	25 48	
Supplies and repairs	200 59	
Telephone	71 10	
Insurance	16 50	
		1621 25
Office expenses		452 92
Proceedings		1259 31
Information Committee . . .		148 85
Library		153 98
Luncheons		551 00
Total disbursements . .		5867 31
CASH BALANCE, DEC. 31, 1902,		**1341 86**
		$7209 17

Respectfully submitted,

Geo. T. Gwilliam, *Treasurer.*

Philadelphia, Jan. 3, 1903.

We have examined the books and accounts of the Treasurer, compared them with the original vouchers, checks, and bank books, and find them to correspond with the Treasurer's statement submitted above.

W. P. Dallett,
H. W. Spangler,
Rich'd L. Humphrey, } *Auditors.*

January 14, 1903.

CORRECTIONS.

In a paper on Fire Mains, by John C. Trautwine, Jr., published in Proceedings of the Engineers' Club of Philadelphia, Vol. XX, No. 1, January, 1903, pages 56 and 64 (pages 16 and 24 of reprint) appeared the following statements respecting the Philadelphia system :

"The present system was designed by the Bureau of Water, Mr. John Wallace Weaver being the engineer in charge of this special work. Mr. Weaver's force consisted of two draftsmen and one inspector, and the expenses of his office, from March 1, 1901, to January 1, 1902, were $3043.38, of which salaries amounted to $2533.60, surely not a lavishly extravagant expenditure, under the circumstances."

"Mr. Weaver estimates the annual cost of operating such a plant with steam at $15,300 and with gas at $11,700, showing a saving, for gas over steam, of $3600 per annum. This estimate is based upon a plant of 16,000,000 gallons daily capacity, with an average of one fire, of ten hours' duration, per month."

Mr. Weaver calls attention to the fact that the drawings and specifications, together with the estimate of operating expenses, were made in the drafting room of the Bureau of Water, under the direction of Mr. F. L. Hand, Chief of that Bureau, that the contract for the pipe had been awarded by the Director of the Department of Public Works before Mr. Weaver's engagement in connection with the work, and that his (Mr. Weaver's) duties consisted in the superintendence of the laying of the mains in the streets.

On page 78 of the issue mentioned (page 38 of reprint), line 7, Milwaukee is credited with the largest fire-boat capacity of any city where fire mains are laid ; but the figures given on the same page show that this distinction belongs to Buffalo.

Henry J. Hartley.

TWENTY-FIFTH PRESIDENT OF THE CLUB, JANUARY 18, 1902—JANUARY 17, 1903.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XX. APRIL, 1903. No. 2

ADDRESS BY THE RETIRING PRESIDENT.

HENRY J. HARTLEY.

Read January 17, 1903.

In casting about for material from which to construct the customary address of the retiring President, I am confronted with the difficulty of finding anything entirely new or original, as, in these days of general distribution of knowledge of current events, through the medium of the numerous scientific publications, all matters are made familiar to the general public, even before actual work is commenced. Consequently, a mere résumé of the past achievements in the engineering line becomes as monotonous as an oft-recited story.

The profession of engineering, in a broad sense of the term, has steadily grown from the earliest ages known until the present day, when it stands not only pre-eminent to all other professions, but is further destined to greater achievements than at present within the comprehension of man; and to even name it would doubtless appear to many as the idle workings of a visionary mind, notwithstanding we have lived to realize, in the Holland submarine boats, Jules Verne's visionary idea of traveling "leagues under the sea"; also the Corinth Canal, contemplated by Julius Cæsar and later actually commenced by Nero breaking ground for the project; but it was soon abandoned and lay dormant for nineteen centuries before being revived.

The sphere of the engineer is broad and lofty, and his services are called into command for carrying to a successful termination all enterprises within the domain of natural science. It matters not how difficult the problem may be, it is to the engineer that we reliably look for the surmounting of any and all obstacles.

It is recorded of Napoleon Bonaparte, when contemplating his campaign into Italy and being reminded by his counselors of the difficulties attending the transportation of such a large army across the Alps, that he pointed to his engineers and remarked: "There is my engineering corps; there will be no Alps." Whether this be truth or fiction, it is illustrative of the importance of the engineer's skill, even in the transportation of armies, and is supposed to have brought about the construction of the Simplon Pass, which is looked upon and spoken of as a wonderful military road, costing over three and a half million dollars.

In the absence of authentic data as to the first engineering feat, we know that the pyramids of Egypt stand among the earliest monuments to the science; we also know that everything accomplished since the period of their erection to the present time, in the way of constructing canals, bridging and tunneling of rivers, improvement of harbors, building of military roads and fortifications, railroads, steamships and vessels of every class, is a proof and living testimonial of what the engineer has done in the past.

As to the future, one is appalled at the thought of what he may be called upon to do. The late scheme of the Pennsylvania Railroad Company to tunnel New York Harbor, as well as Manhattan Island, surely furnishes food for enough thought to carry the mind of the engineer to the feasibility, and possibility at some future time, of tunneling the English Channel, thus making an all-rail communication between two of the largest cities in the world—London and Paris—and thereby reducing the time of travel to a minimum and making the journey one of pleasure instead of discomfort. The realization of this mooted enterprise, however, depends entirely on the future advancement of civilization of the contiguous nations, in their willingness to submit their international differences to an international board of arbitration for adjustment. The same applies to the bridging of rivers that are now restricted in that respect for military reasons.

The first quarter century of the existence of our Club has just closed, and the anniversary was fittingly observed and celebrated by our members. In the retrospect of that period great engineering

feats have been accomplished universally. Those worthy of mention, although familiar to every one, command passing notice as engineering achievements during the past twenty-five years, a few of the most important being the construction of the Tay and Forth Bridges, the Mersey Tunnel, the Manchester Canal, the Trans-Siberian and Manchurian Railroad, and lately the great irrigation storage dam constructed by the British government at Assouan, on the Nile, commenced in 1898 and completed in 1902, at a cost of £2,400,000; storage capacity, 1,165,000,000 cubic meters. It has been accepted in Egypt that no one in any way connected with the dam shall write of its construction before Mr. Maurice Fitz Maurice's paper on the work has been read at the Institute of Civil Engineers. The storage capacity of this dam is, then, nearly 400,000,000,000 gallons of water—sufficient to irrigate enough fertile land (now unproductive) to insure a revenue to Egypt estimated at $75,000,000 to $100,000,000 per annum. The foundation-stone was laid with appropriate ceremonies by the Duke of Connaught on February 12, 1899, and dedicated December, 1902. As "everything of value comes out of the ground," it is hoped that the successful completion of the great dam of Egypt will have the effect of stimulating to a consummation the proposed work of our government—water-storage and crop irrigation in our own country. This work is now in the hands of the Secretary of the Interior, whose Chief of the Division of Hydrography in the United States Geological Survey, Mr. F. H. Newell, has full charge. He has recently published over his signature an outline of the vast amount of work to be done by the government in the matter of public irrigation throughout the West. The consummation of this vast project will open up a large field for the engineering profession.

The great sewerage canal at Chicago, constructed at a cost of $30,000,000, may also be mentioned as a great engineering feat for the accomplishment of the drainage of that city. It has practically reversed the flow of the Chicago River from Lake Michigan to the Mississippi River. Though not entirely effective at present in removing the sewerage from the Lake, it is to be made so by a drainage canal extending from the Calumet River, which now flows into the Lake, through Sag Valley, to the existing main sewerage canal. The estimated additional cost has been figured at $12,000,000. This, with the intercepting sewers now under construction along the Lake shore, when completed so as to prevent all sewerage from entering the Lake, will assure a pure water-supply for the city of Chicago.

The long-talked-of enterprise—the harnessing of Niagara Falls—has been accomplished by the Niagara Falls Power Company, to the extent of the developing of 110,500 horse-power by the installation of ten turbine wheels erected in what is known as Pit No. 1, each developing 5000 horse-power through a generator running at 250 revolutions per minute (these were designed by Messrs. Picard & Faech, of Geneva, Switzerland), and eleven turbine wheels, installed in Pit No. 2, each developing 5500 horse-power through a generator running at 250 revolutions per minute, designed by Mr. Escher Wyss, of Zurich, Switzerland. The plant was built and installed by the I. P. Morris Company, of Philadelphia, under the supervision of Dr. Coleman Sellers, engineer for the Niagara Falls Power Company. The work was commenced in 1891 and is about being brought to completion. The total amount of power generated is absorbed by the Buffalo and Niagara Trolley Line, and numerous industrial establishments recently located there for the advantages of the power, commercially. Since the establishment of this industry the city of Niagara has increased in population about 35 per cent. The same company has commenced work on the Canadian side, and by the close of the year will have installed a plant there of a similar nature.

Our local improvements during the same period must not be overlooked. Noticeably among them are the improvement of the harbor of Philadelphia by the removal of the islands from the Delaware River and the widening of Delaware Avenue, the spanning of the Delaware River at Pea Shore by a steel pivoted draw railroad bridge, a vast increase in storage capacity for better water-supply, including filter beds in course of construction, and of capacity sufficient to supply the whole city with pure water. In connection with this subject I quote from the last city reports: "To the close of 1901 a total of $15,700,000 had been provided for the improvement of the water department, in settling reservoirs, filter beds, pumps, conduits, etc., and contracts have been awarded for filter beds with an aggregate capacity of 154,000,000 gallons, besides a 73,000,000-gallon settling reservoir; also four filtered water basins of a combined capacity of 77,500,000 gallons, 90,000,000 gallons of pumping facilities, a 3,000,000,000-gallon filtered water conduit, and 31 miles of water-mains."

The foregoing work, as quoted, is under the supervision of the following gentlemen: Mr. Frank L. Hand, Chief of the Bureau of Water; Mr. Geo. S. Webster, Chief Engineer of the Bureau of Surveys (members of The Engineers' Club of Philadelphia); Mr. John W. Hill,

Chief Engineer of Filter Plant; and Mr. Wm. C. Haddock, Director of Public Works, city of Philadelphia.

Other local improvements during that time, which were sorely needed, consist of well-paved and well-lighted streets, a deliverance from the old horse cars to the electric system, which is much faster, cleaner, and has the advantage of an extension of travel far into the rural districts; the abolishing, to some extent, of grade crossings, made possible by the subway system and terminal facilities of the Reading Railroad Company by entering the city at Market Street; and also by the Pennsylvania Railroad Company, in their system of elevated tracks from West Philadelphia to Broad and Filbert Streets.

Of our local industrial establishments within the city limits, the Baldwin Locomotive Works, during the last quarter century and within the existence of the Club, has turned out, including all classes, the unprecedented number of 17,267 locomotives, of an aggregate weight, including tenders, of 720,000 tons; and if coupled together on a railroad track would cover a distance of 162 miles. Of the number given, 230 are electrically driven and 50 have compressed air for propelling power; the remainder, steam. I am indebted to Mr. Wm. Penn Evans, of the Baldwin Locomotive Works, for kindly furnishing this information.

The William Cramp & Sons Ship and Engine Building Company, since the birth of the new navy, in 1887, has completed for the United States government, including all classes of war vessels, six protected cruisers, with a total displacement tonnage of 28,500 and an aggregate indicated horse-power of 72,900; four armored cruisers, with a total displacement tonnage of 45,000 and an aggregate horse-power of 81,500; five battleships, with a total displacement tonnage of 55,700, and an aggregate horse-power of 56,400; besides one first-class protected cruiser of 4900 tons displacement, with an indicated horse-power of 15,277, developing a speed of 22½ knots, for the Imperial Japanese Navy; also, for the Imperial Russian Navy, one first-class battleship of 12,750 tons displacement, having an indicated horse-power of 18,255, developing a speed of 18 knots; and one first-class protected cruiser, of 6500 tons displacement, having an indicated horse-power of 17,059, developing a speed of 23¼ knots.

As time and space will not permit of going into the details of each of the foregoing vessels, I select the last battleship completed—the "Maine"—as being probably the best remembered, to give further

data. The following is a general description of the characteristics and qualities of the ship:

General Dimensions.

Length of load water-line, 388 feet.
Beam extreme, 72 feet 2½ inches.
Draught on even keel, 23 feet 10 inches.
Displacement at draught, 12,500 tons.
Indicated horse-power, 16,000.
Speed per hour, 18 knots.
Coal capacity, 2000 tons.

Armament.

Four 12-inch breech-loading rifles.
Sixteen 6-inch rapid-firing guns.
Six 3-inch rapid-firing guns.
Six 1-pounder rapid-firing guns.
Two colts rapid-firing guns.
Two 3-inch rapid-firing field guns.
Two submerged Whitehead torpedo tubes.

Armor.

Water-line belt extending the length of the machinery spaces, 7 feet 6 inches in depth, with a thickness of 11 inches, tapering to a thickness of 4 inches at the bow.

The main belt extends aft to about the after barbette.

Above the main belt the vessel is provided with casemate armor, 6 inches in thickness, extending to the upper deck.

This belt protects both the stability of the vessel and the battery of 6-inch rapid-firing guns.

The 12-inch guns are mounted in barbette turrets placed in central line of the vessel, one forward and one aft, each turret containing two guns; the armor on the turrets being 12 inches in thickness with a face-plate, and 11 inches for the balance of the armor.

The barbettes are 12 inches in thickness, except at the rear, where the armor is reduced to 8 inches.

The protective deck is worked in the well-known trapezoidal form, being flat in the central portion and sloping down below the water to the armor shelf at the sides. The plating on the flat is 2¾ inches thick and on the slopes 3 to 4 inches thick.

Above the slopes of the protected deck coffer-dams are worked, filled with cellulose for further protection of the stability of the vessel.

The vessel is provided with quarters for 40 officers and 511 men, and furnished throughout with the most improved accommodations for the officers and men.

The engines are of the well-known inverted triple-expansion type, driving twin screws, and steam is generated from 24 water-tube boilers of the Niclausse type.

The vessel is provided throughout with electric lights, incandescent system; also fitted with powerful search-lights, as is the custom on vessels of the United States Navy.

Two masts, of military tops, are fitted, each being provided with platforms for rapid-firing guns and three search-lights.

Full complement of boats, both steam and rowing, usually prescribed for vessels of the United States Navy, is provided, these being handled by boat cranes operated by electric motors.

The armor throughout has been tested by the Krupp process, and every improvement of standard character has been incorporated into the general design and outfit of the vessel.

This is but a small portion of what has been accomplished in the first quarter century of the existence of the Club. Who can conjecture what will be done during the next quarter century in the engineering line?

I will now close with a word of thanks to my associates in the administration of the affairs of the Club during the past year, and to the members of the Club as a body, for their attendance and interest in our meetings and their co-operation and approval of our actions.

MANUFACTURE OF CEMENT FROM MARL AND CLAY.*

HENRY S. SPACKMAN.

Read December 20, 1902.

The chemical elements necessary for the manufacture of Portland cement are lime, silica, and alumina, the last two being generally supplied by some form of clay or shale, the average ratio being one part clay to four parts carbonate of lime.

In the United States the lime used in the manufacture of Portland cement is found in several forms, which may be classified under three general groups,—argillaceous limestone, marl, and limestone,—the latter group being capable of considerable subdivision.

Considering these in the order of their relative importance in the cement industry, the argillaceous limestone is easily first, although its supremacy is threatened, the output decreasing from 72 per cent. of the production of the United States in 1900 to about 61 per cent. of the estimated production for 1903. The principal deposit of this material is found in eastern Pennsylvania and New Jersey. The most eastern development is at New Village, where the Edison Portland Cement Works are located. The Vulcanite and Alpha Works are a little south and nearer the Delaware River. The next development is at Nazareth, where a number of works are in operation and in course of construction, and the deposit can be traced across the country to the Lehigh River at Siegfried. Here are located the various works of the Coplay, Atlas, American, Lehigh, Lawrence, Whitehall, and Bonneville Cement Companies. There is no development of the deposit between here and the works of the Reading Cement Company at Molltown, which is probably due to the fact that there are no adequate railroad facilities. From the works of the Edison Company to those of the Reading Company is a distance of about fifty miles, and with the exception of the eastern end the bed as developed does not appear to be over three or four miles in width. In appearance the argillaceous limestone resembles slate, and in chemical composition it varies within the following limits:

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* Discussion will appear in the July issue of The Proceedings.

Silica (SiO_2), ...	10.00 to 19.00
Alumina and Iron Oxide ($Al_2O_3 + Fe_2O_3$), ...	4.50 " 8.00
Lime (CaO), ...	38.00 " 48.00
Magnesia (MgO), ...	1.00 " 2.00

The next in order of output is limestone and clay, large works manufacturing Portland cement from these materials being located in New York, Ohio, Illinois, Virginia, Indiana, Missouri, and other States, all erected in the last four or five years, forcing marl cement from second place in 1902.

The last in the present order of output, but probably second in amount of capital invested and men employed, is marl. Perhaps a fourth should be added,—furnace slag,—from which considerable cement is being manufactured. Slag cement is manufactured in two ways: One method is simply a mechanical mixture of slag with hydrated lime, and the cement so manufactured is more correctly a puzzolana. By the other method a true Portland cement is produced, the slag being treated as a low-grade limestone, to which sufficient lime is added to secure a correct analysis, the raw materials being ground, mixed, and burned the same as for Portland cement.

The mechanical equipment of a cement plant varies with the raw materials used, each requiring a different treatment; but the general principle is the same, the object being to secure a fine grinding and thorough mixing of the raw materials previous to calcination.

In the dry process which is used for argillaceous limestone, limestone and clay, and slag, you have as a rule hard materials which are fairly constant in their chemical composition and carry comparatively little moisture, while in the wet process which is used principally for marl the materials dealt with are soft in character, often semi-liquid, carrying, as they come from the deposit, from 40 to 50 per cent. of water, and, with some methods of dredging, more. After calcination there is no great difference in the nature of the clinker, and the finishing departments of the different types of mills would be interchangeable.

Marl is of organic origin, the deposits being found in low lands, marshes, and the bottoms of lakes. In texture it is smooth and soft, varying in consistency from that of putty to that of river mud. While the greater majority of the shells are entirely decomposed, about 90 per cent. of the marl under ordinary conditions being found fine enough to wash through about a No. 100 sieve, some of the shells still retain their form. The majority of these resemble the ordinary snail shell in appearance, and vary in size from 1 and 2 inches to those that

are almost microscopic. In addition to these are found the shells of the fresh-water mussel, apparently of more recent date, which are sometimes as large as your hand. I submitted some of the shells taken from a deposit in Michigan to the Academy of Natural Sciences in this city, and Mr. H. A. Pilsbry wrote me in regard to them as follows:

"The shell-fish mentioned in your letter of November 20th as found in a marl deposit in Michigan—viz., *Planorbis campanulatus, Planorbis parvus, Limnæa stagnalis, Limnæa humilis, Physa ancillaria, Amnicola lustrica*—are all still existing as living species. The marl in question is doubtless a comparatively recent deposit occupying the bed of a post-glacial lake or pond. Similar deposits occur in northern New Jersey, where the beds of post-glacial ponds have become filled with calcareous material, largely molluscan shells.

"The cooler climate and great number of ponds and lakes which followed the glacial period favored the multiplication of fresh-water mollusks, which at that time were evidently more abundant than at present, now that the vast majority of these ponds have become extinct by cutting down of streams to their beds and diminished rainfall, etc. However, the same shell-fish may still be found in many Michigan lakes to-day. As a general rule, it requires some search to find them, except in early spring and in the fall, when they are abundant enough in suitable places."

I have never observed any living specimens in the deposits examined, except a few of the ordinary fresh-water mussel.

In northern Ohio, near Sandusky, the marl deposits are of a different character, being largely of a chemical origin formed by the crystallization and deposit of lime through evaporation of the water which overflowed the low lands in periods of flood, etc. Springs in this neighborhood, which come up through the clay subsoil, carry a high percentage of lime, in some instances as high as forty grains to the gallon. Large pieces of considerable hardness are frequently found, and these are known locally as prairie rock or petrified marl, and they resemble coral in their general appearance. On breaking pieces of this rock, the outline of rushes and water plants can be followed, which have apparently been incrusted during the process of crystallization and afterward decomposed, leaving in the travertine a cast of the plant. These stones are found in conjunction with granular marls, and are often of considerable size. I have only seen marl of this character in the vicinity of Sandusky, but there are deposits in

New York State and elsewhere. In the organic marl deposits small quantities of travertine are found, generally under water and in shallow places, the precipitation being probably due to chemical action caused by plant life.

The deposits of marl vary in size and depth and in many instances are covered with several feet of muck. The mollusks, from the shells of which the marl is formed, must have been very abundant at the time of the formation of these deposits, as myriads of shells would be required in their formation, and the conditions immediately following the glacial period must have been exceptionally favorable for this form of life. They would appear to have flourished best in shallow waters, and it will generally be found that where the water is over thirty feet in depth there is no marl under it, although fluctuations in the depths of the lakes may cause this rule to be departed from. I have observed that almost all of the lakes have an old beaver dam at the mouth, which at a later period had been reinforced by the dams of the lumbermen, which are now falling rapidly into decay. From the appearance of the deposits I would imagine that the various species of mollusks flourished along the edges in the shallow water, and gradually encroached on the lake itself, although it is possible that through the work of the beavers already mentioned the shallow lakes were gradually increased in depth and the marl deposits built up in this manner. With the exception of the presence of vegetable matter near the surface, there is no apparent difference in the analysis of marls taken from the swamps and low lands and from the lakes, where it was covered from one to ten feet with water.

The deposits vary in depth from a few inches to thirty feet, but should average at least ten feet for profitable working. The surface above low water and shallow portions of the lakes are generally covered with a vegetable growth, the peat and muck running from a few inches to several feet, and this has to be stripped before the marl is excavated. If the water is over two feet in depth, the marl is generally clean.

There are few lakes or swamps in Michigan, northern Indiana, and the various portions of Canada bordering on Lake Huron, Lake Erie, and Lake Ontario, that do not contain marl to more or less extent, and I know of one deposit in Lake Huron itself. This deposit in Lake Huron is rather curious and is located a few miles north of Alpena. It has formed between a small island and the main shore. Drifting sands have practically closed the channel at one end, and the entire bay inside was filled with marl to a depth of about ten feet. The marl

however, was very soft, and an oar stuck upright in it would sink through it by its own weight. While the shells from which the marl was formed were practically pure carbonate of lime, the chemical composition of the marl varies, due to the amount of vegetable matter it contains, and also to silica, which appears to have been blown in by the wind in the form of sand. Sometimes the sand is found in layers and at other times it is mixed through the marl itself. Its presence does not seem to have been caused by the wash from streams feeding the lakes, as the marl is found to be as pure, if not purer, at the mouth of streams emptying into the lakes, as in the other parts. While the vegetable matter does not directly affect the quality of the cement produced, as it is burned during calcination, it affects the value of the deposit commercially, as marl high in vegetable matter requires more fuel in its calcination and a greater bulk of marl has to be handled. If the sand is found in any large quantities,—say over 3 per cent.,—it is very objectionable, as unless finely ground it will not combine with the lime during the passage through the kilns, and, when finely ground, it requires a higher temperature to secure combination with the lime. Marl varies in its chemical analysis considerably, but for the successful manufacture of cement it should be within the following limits:

Silica (SiO_2),	00.00	to	3.00
Alumina and iron oxide ($Al_2O_3 + Fe_2O_3$),	trace	"	5.00
Lime (CaO),	45.00	"	56.00
Magnesia (MgO),	00.00	"	1.50
Sulphuric anhydride (SO_3),	00.00	"	1.00
Organic matter,	00.00	"	5.00

Marl deposits are plentifully scattered throughout the States bordering on the Great Lakes and in Canada, the eastern limit seeming a line drawn from Syracuse, N. Y., to about one hundred miles east of Kingston. The western line extends into Illinois and up into Wisconsin, the southern limit being about two hundred miles from the Great Lakes. On the north, in Canada, marl is rarely found at a distance of over one hundred miles from the Great Lakes. I do not know of any deposit north of Lake Superior.

At all the larger mills the marl is excavated by mechanical means, some form of dredge or steam shovel being used. Marl is transported to the mill in various ways. If the surface of the deposit is above water and sufficiently firm, tracks are laid and cars are used; but if soft and covered with water, it is either pumped direct from the dredge to the mill or loaded into scows, in which case it is generally

pumped from the landing to the mill, the method of handling varying with the conditions at each plant and the ideas of the designer.

Fig. 1.—Opening up Marl Beds.

Fig. 2.—Steel Roof Overlooking Marl Lake.

The first mills built to manufacture Portland cement from marl and clay in the rotary kilns attempted the preliminary drying of the raw

materials before grinding and mixing, but the results, so far as I can learn, were not satisfactory, due possibly to the fact that when these earlier mills were built, the cement industry was in its infancy and mechanical devices for its manufacture were not so fully developed as at the present time.

The question of drying the marl previous to the manufacture of cement is again being taken up, and I understand several mills are being designed on this principle, and one or two small ones are in operation. While there is no question in my mind as to the mechanical practicability of the drying of marl as the first step in its manufacture into Portland cement, I question whether it will be found as economical

FIG. 3.—INVESTIGATION OF MARL DEPOSIT.

as the wet process, or will ever be commercially successful, and await with interest the results in a large mill now being built near Bay City, Michigan, where I understand it is proposed to dry the marl at the deposit, ship it a considerable distance by rail, and then manufacture it into cement. The conditions at this deposit, however, are more favorable for the success of the experiment than any other I have ever seen, as the lakes in which the marl is found are so located that with comparatively little work the outlet streams can be lowered and the water drained from the lakes. The deposits were examined by the writer's firm some years ago, and it was suggested that the outlets of

the lakes be lowered, a channel cut the entire length of the lake, from which others would run at right angles to the shore, and that in this condition it might gradually dry out.

A rough experiment was made to determine the effect of drainage of the marl. A considerable quantity of marl was piled in a room, the temperature of which was about 70° or 80° F., but the moisture was lost very gradually. After two weeks a sample was taken from the center of the pile, and on the moisture being determined it was found to contain 32 per cent., the marl originally carrying about 50

Fig. 4.—Launching of Scow.

per cent., and I question whether by any system of drainage the moisture in the marl could be reduced much below 30 per cent.

In the manufacture of cement from marl and clay it is necessary to add a considerable amount of silica and alumina, which is generally furnished by clay. For the wet process this is preferably plastic in character, and should be low in magnesia and lime and free from sand and pebbles, the combined iron and alumina in the clay being from one-half to one-third of the silica.

In the vicinity of marl deposits there is generally an abundance of clay, but it is difficult to find a deposit suitable for the manufacture of Portland cement, the majority carrying an excessive amount of magnesia, and where the magnesia is low there is apt to be an undesir-

Fig. 5.—Marl Dredge and Clam-shell Bucket.

able percentage of unavailable silica present in the form of sand. A number of mills started without giving the clay-supply careful consideration, and are now compelled to bring their clay from Ohio

Shales are found in Michigan which are of good chemical composition for the manufacture of cement, but I know of no plant which is using them for their clay-supply.

Turning to the mechanical construction of a marl plant, the first problem that confronts the designer is the excavating of the marl and the delivery to the mill. This has been treated in several ways, continuous bucket dredges, dipper dredges of the clam-shell or the orange-peel type, pneumatic or hydraulic dredges all being used, but the latter process has not been found as successful as the other, owing to the large percentage of water brought up with the marl and the difficulty of separating the muck and other impurities from the marl. In some plants the marl is dredged and submitted to the preliminary preparation on the dredge, the marl being afterward forced through a pump line to the mill. Probably the most successful machine for the preliminary preparation of the marl is one resembling a mammoth sausage-grinder, which in its principle is identical with the "Universal" meat-chopper. The machine consists of a hopper of sufficient size to receive from 1 to 2 yards of marl at a time. Underneath this hopper is a powerful screw conveyor which forces the material against a perforated plate, the holes in the plate being about one-half inch in diameter. The soft marl is forced through these holes, while the grass, roots, stones, etc., are discharged from the bottom.

I have had no personal experience with the pumping of marl from the dredge to the mill, but understand that the most successful device is a double cylinder with compressed air, the marl itself acting as a piston, the device consisting of two tanks which are alternately filled and emptied. After the tank is filled, the compressed air is turned on and the contents forced into the pipe line. In the mills where I have been connected with the design, the conditions have favored the handling of the material in cars, as the greater portion of the marl deposits were above water. Tracks were laid out on the marsh and the cars run directly to the dredge, a mattress of brush being used on the softer parts. On reaching the mill the marl is dumped into a separator or pugging conveyor, thoroughly breaking it up; the marl, which is now in a semi-liquid state, being about the consistency of grout, is stored in tanks or concrete pits. The clay, which is generally brought from some distance, is then added to the marl in correct proportions. It has been customary to dry the clay, grind it, and mix it with the marl at the pug mill, but in the mill of the Detroit Portland Cement Company, which has just been started, a departure was made

and the drying omitted, the two materials being reduced to a slurry separately.

On delivery at the mill the clay is first passed through a disintegrator and then into a pugging conveyor, where sufficient water is

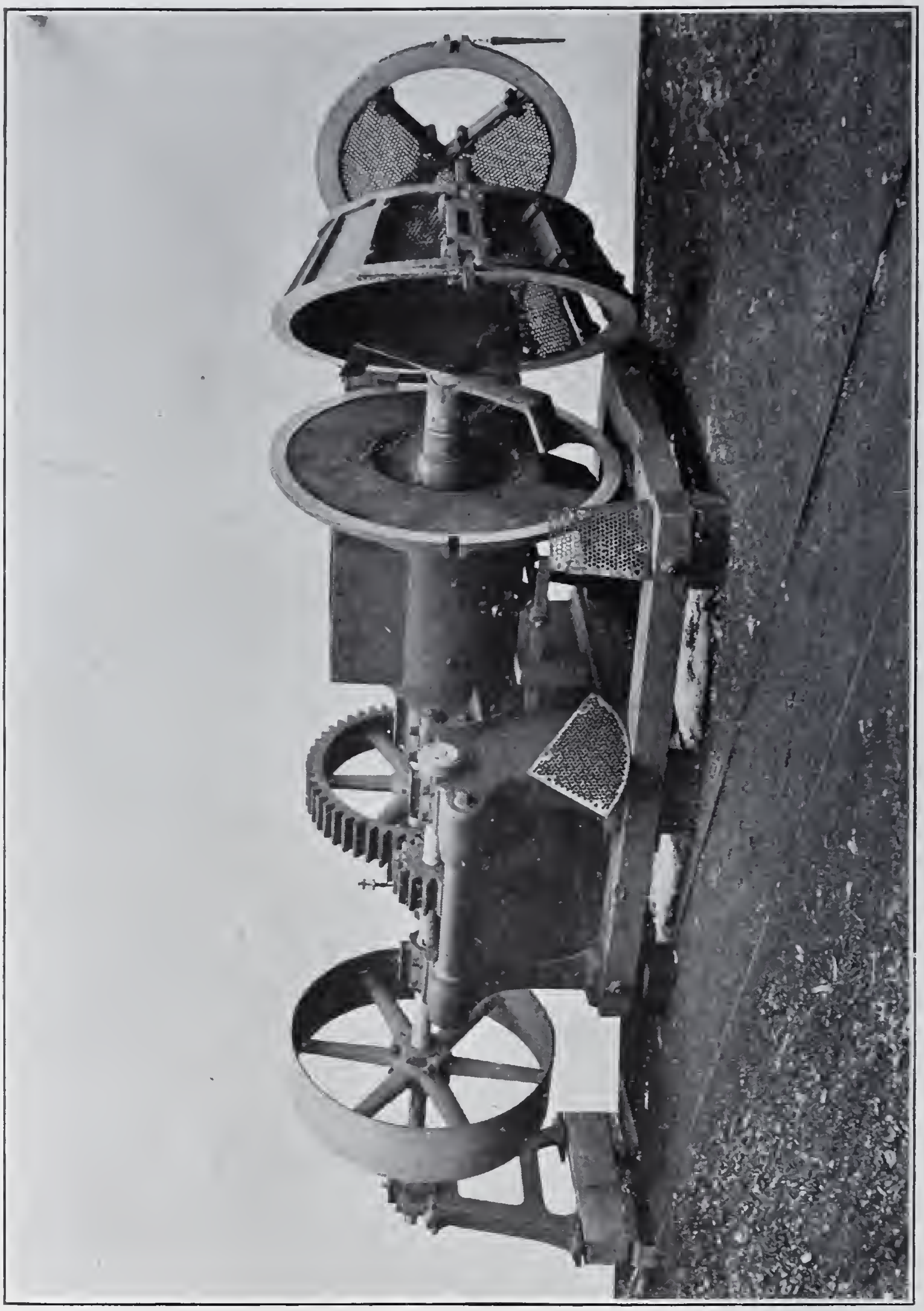

Fig. 6.—Stone and Grass Separator for Marl.

added to bring the clay to about the same consistency as the marl, and the clay is run to storage tanks, from which it is pumped with the marl into the mixing tanks, the proportion being roughly one cubic

foot of clay to four cubic feet of marl. In the mixing tanks the slurry is subjected to thorough agitating, and the slurry is then ground to such fineness that 95 per cent. will pass a No. 100 sieve.

The handling of the raw materials after delivery to the mill is done by pumps, three types being in use,—cylindrical pumps, centrifugal pumps, and compressed-air pumps,—as previously described.

For grinding the marl the wet tube-mill has been most generally used, although in some of the Canadian mills which I visited this fall millstones were used with excellent results. After grinding, the slurry is stored in large tanks, where a final analysis is made, and if necessary

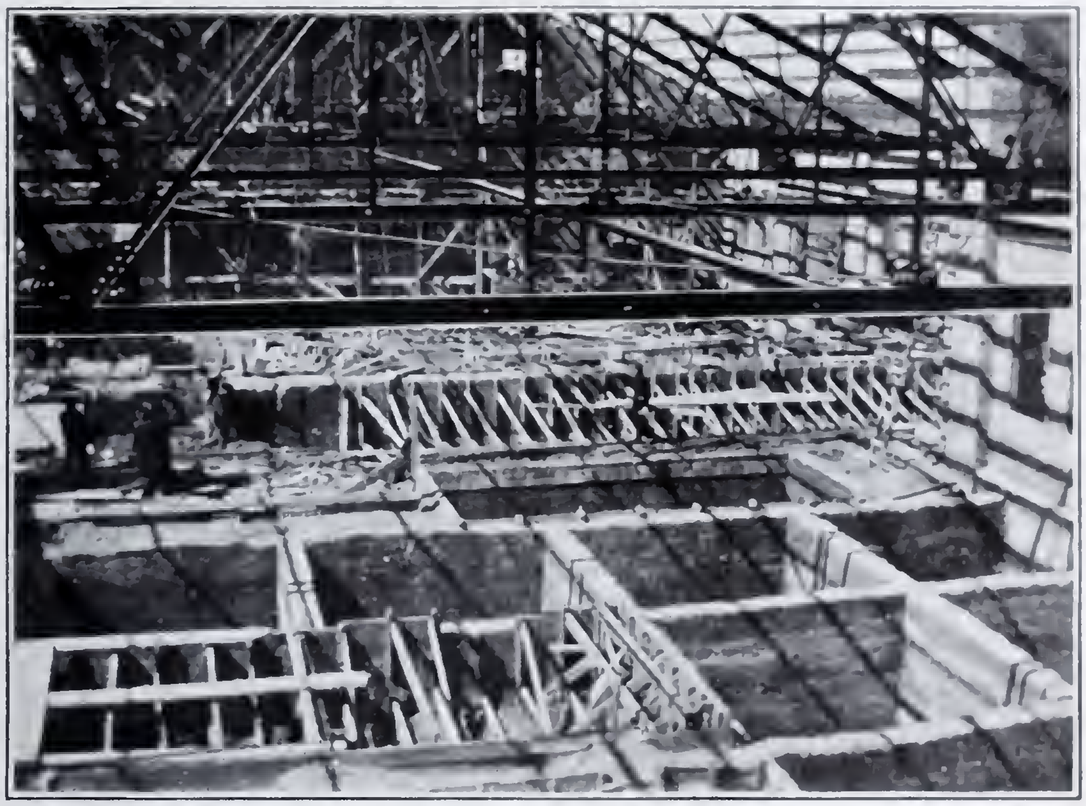

Fig. 7.—Mixing Tanks.

the mix is corrected. From these tanks the slurry running from 40 to 50 per cent. of solid matter is pumped directly into the kilns, where it is dried by the waste heat, this drying taking place in the first twenty feet of the kilns. Kilns for burning by the wet process are generally made longer than those used in the dry process. The stack temperatures in the wet process are considerably lower than in the dry process, and operation shows that the calcination of the slurry consumes considerably more coal than in the dry process. I am of the opinion, however, that this increased coal consumption is not entirely due to the amount of water in the slurry, but to the more refractory char-

acter of the raw materials, and to the decreased production. In one mill some experiments were carried on to determine stack temperatures in connection with the consumption of coal, and it was found that with a stack temperature of about 400° F., the best all-around results were obtained. In the dry process the stack temperatures run from 800° to 1200° F., and, if the kiln is being forced, even higher.

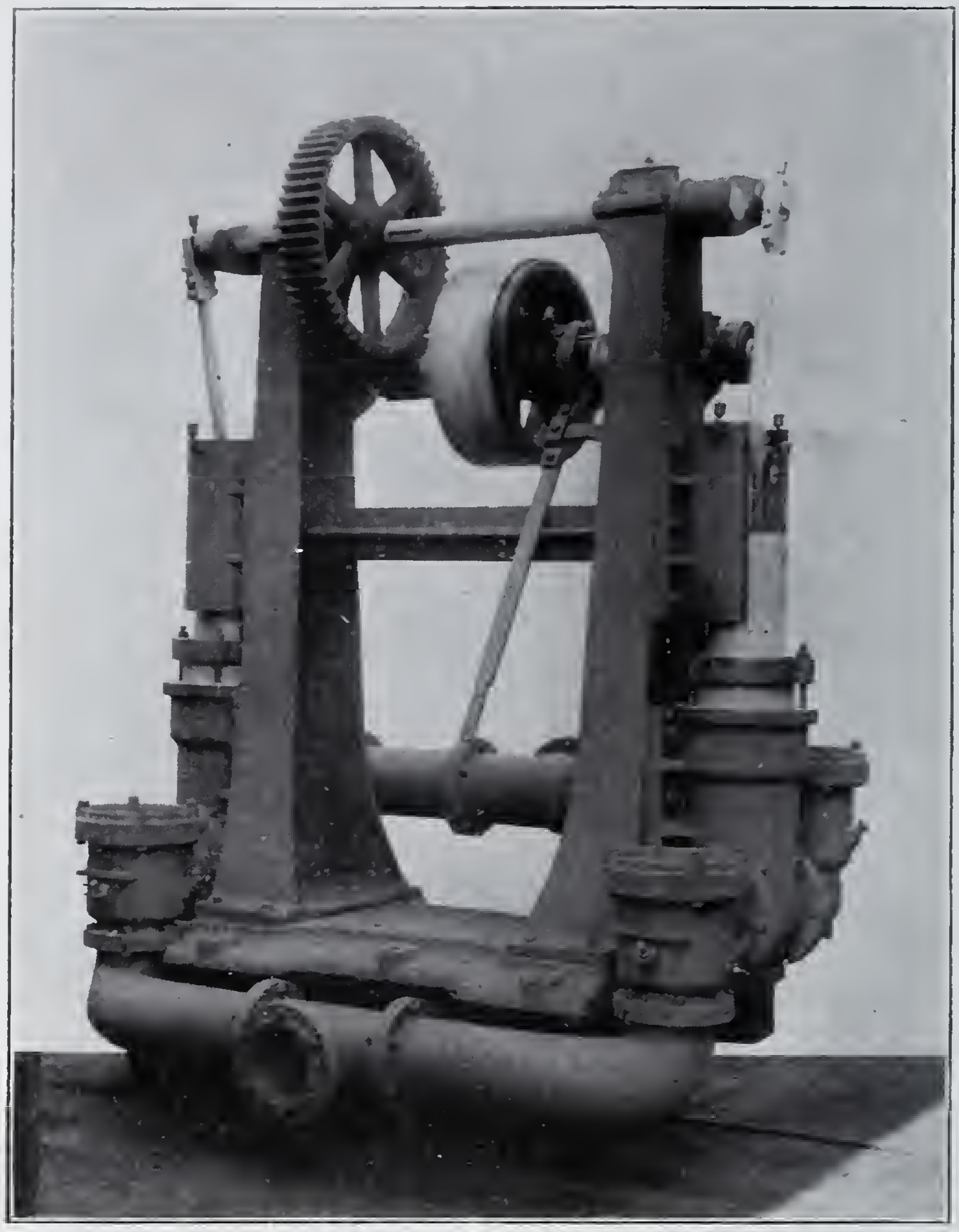

Fig. 8.—Cylindrical Pump.

The use of powdered coal in the burning of cement has now become almost universal, and with the exception of one or two small mills in California and Texas, oil has been entirely superseded. One mill is operated on natural gas; but I have been unable to secure any data as to capacities and outputs.

In ordinary practice the burning of cement by the wet process is more expensive for two reasons: First, there is an increased consumption of at least 50 pounds of coal per barrel of cement produced, and a decrease in production per kiln of about 50 per cent. While some mills claim to be producing by the wet process 125 to 135 barrels per kiln per day, I do not think the average is much more than 100 barrels per kiln; while by the dry process a production of over 200 barrels per day per kiln is not unusual, and I should think an average of the production of all the dry mills would show that 175 barrels has been attained, with a coal consumption of about 110 pounds, some mills where the material is easily fused dropping as low as 90 pounds.

I was very much surprised to see a record of one week's run in a cement mill recently that showed, with five kilns in operation, a production of 256 barrels of cement per kiln for each twenty-four hours, with a coal consumption of $89\frac{6}{10}$ pounds of coal to the barrel of cement produced. I think that record is greater than any I have ever heard of, and it is an absolutely correct one, as all the coal is weighed going into the kilns and all the cement coming out.

After burning the clinker, the process of manufacture differs in no way from that in use in the dry plants, the marl plants having an advantage over the dry plants from the fact that the clinker is more readily ground.

Comparing the manufacture of cement from marl and clay with the manufacture of cement from the argillaceous limestone of the Lehigh region, or from limestone and clay, the principal advantages and disadvantages are as follows:

In the manufacture from marl and clay the excavation and grinding of the raw materials are much less difficult, as the materials are all soft; but to counterbalance this you have the following disadvantages:

First, with each 100 pounds of raw material you have to handle 100 pounds of water.

Second, after starting manufacture the raw materials cannot be left at rest, but must be agitated.

Third, an increased fuel consumption of 50 per cent.

Fourth, difficulty of operating in cold weather.

Fifth, reduced production per kiln.

These offset any advantages gained by the softer character of the materials.

This general review of the conditions will serve to make the accompanying illustrations clearer and more easily understood.

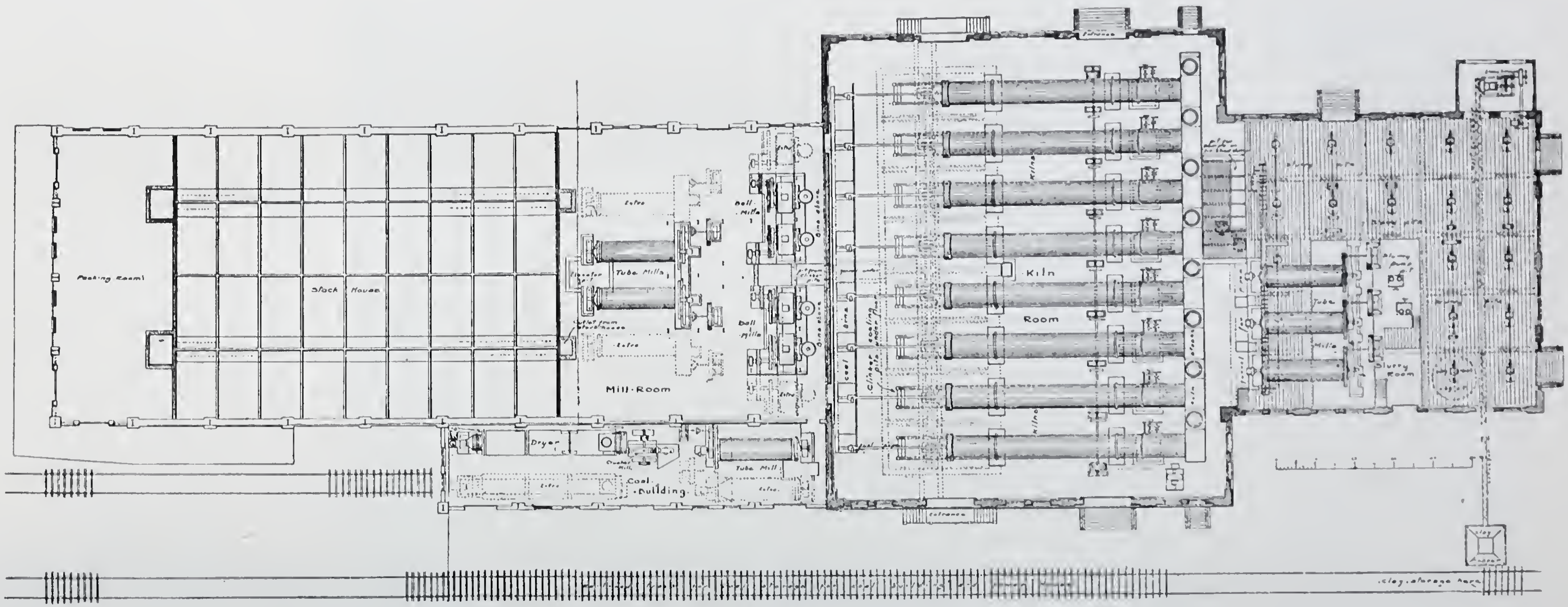

FIG. 9.—GROUND PLAN OF MILL BUILDINGS.

Figure 9 shows the ground plan of the mill which was designed for a capacity of 1000 barrels of cement per day. The exact location of tracks, etc., has been modified from this preliminary study, but in general the mill as built departs little from the drawing.

The marl is excavated by a clam-shell dredge with a bucket capacity of 1½ yards, which discharges into the cars. These cars are brought to the foot of a double-track incline, up which they are drawn to the second floor of the marl building, which has an elevation of about 40 feet above water-level in the lake. The hoist has a sufficient capacity to haul up two loaded cars, the empty cars returning by gravity. The cars are dumped into a hopper over the separator previously de-

Fig. 10.—Buildings under Construction—Steel Skeleton.

scribed, and from this they discharge into an 18-inch ribbon conveyor which carries the marl to the six separate pits, each of which is equipped with a two-arm agitator revolving at a speed of fifteen revolutions per minute. Compressed air is being substituted for mechanical agitators in a number of the mills, and considerable advantage is claimed for its use.

The clay is brought in by rail, and is unloaded directly into the hopper of the disintegrator, which is located in a building not shown on the plan. After passing through the disintegrator, the clay is discharged into an 18-inch cut flight conveyor, which, in addition to

conveying the clay to the clay storage pits, thoroughly pugs it. It was originally intended that the clay should be discharged into a wash-pit which was equipped with an especially designed four-armed agitator similar to the wash-mill used in Europe, the arms being equipped with drags; the outlets are so arranged that the washed clay could be discharged into three adjoining storage pits. It was, however, found on operation of the mills that the clay was so thoroughly disintegrated and pugged before delivery to the wash-pit, that further treatment was unnecessary, and the clay is now delivered into any of the separate pits without first going in the wash-pit, two of the arms in the wash-pit agitator having been removed. Each of these pits has

FIG. 11.—BUILDINGS NEARING COMPLETION.

a capacity of about 1600 cubic feet. From the storage pits the material discharges through pipes by gravity to the suction of the two pumps located just in front of the storage pits for marl and clay. When mixing the raw materials, a sufficient quantity of clay is first pumped into one of the four mixing pits, then the marl is added; these pits are equipped with high-speed propeller agitators, the two pumps being so piped that one can be working on marl and one on clay at the same time, or both on one material.

After the marl is added to the mixing pit, the mass is agitated for about thirty minutes, and then a sample is taken, the percentage of

lime determined by volumetric methods, and, if the mix is correctly proportioned, the contents of the pits are pumped to three steel storage tanks located over the tube-mills on a platform, if no correction is needed.

The material from these tanks is fed by gravity to the tube-mills which discharge into the five slurry storage pits. The total storage represented by the various pits is sufficient to produce 2500 barrels of cement. The entire proportioning of the raw material is made previous to the grinding, although check analyses are taken from each pit after grinding in order to prevent the possibility of error in the mix.

From the storage tanks the finished slurry is pumped to the kilns, an even pressure being maintained by two stand-pipes through which the overflow returns to the pit from which the slurry is being pumped.

The rotary kilns are of the ordinary type, six feet in diameter, sixty feet long. Each kiln is equipped with a speed regulator, by which its speed of rotation may be varied from one turn in forty-five seconds to one turn in three minutes.

The clinker after passing through the kilns is discharged into the vaults located directly under the kilns, which are of sufficient size to admit of the kiln operating for four days without removing any of the clinker. It was hoped when the plant was designed that this storage would be sufficient to allow of the clinker cooling sufficiently to be delivered directly to the ball-mills. To better secure this end it was intended to force cold air into the bottom of the pits and exhaust it from the top. Experience elsewhere, however, developed the fact that the mass of clinker was so great that thorough cooling could not be obtained, the air seeking preferred channels, and an auxiliary system was put in, rotary coolers being used. The fans exhausting from the top are those used for blowing the powdered coal into the kilns, the air used for this purpose being heated by its passage through clinker. A considerable improvement in the operation of the kilns is effected, and consequent saving of fuel, the temperature of the hot blast being about 700°.

The coal is unloaded directly from the cars to an elevator, which discharges it into the hopper of a rotary drier, from which the material is discharged into a disintegrator which reduces it to such fineness that the majority of it will pass a No. 10 sieve. From this disintegrator the coal is elevated to the bin over the tube-mill, where it is ground to such fineness that 95 per cent. will pass a No. 100 sieve. From the tube-mill the coal is elevated and discharged into the coal bins in front of the kilns.

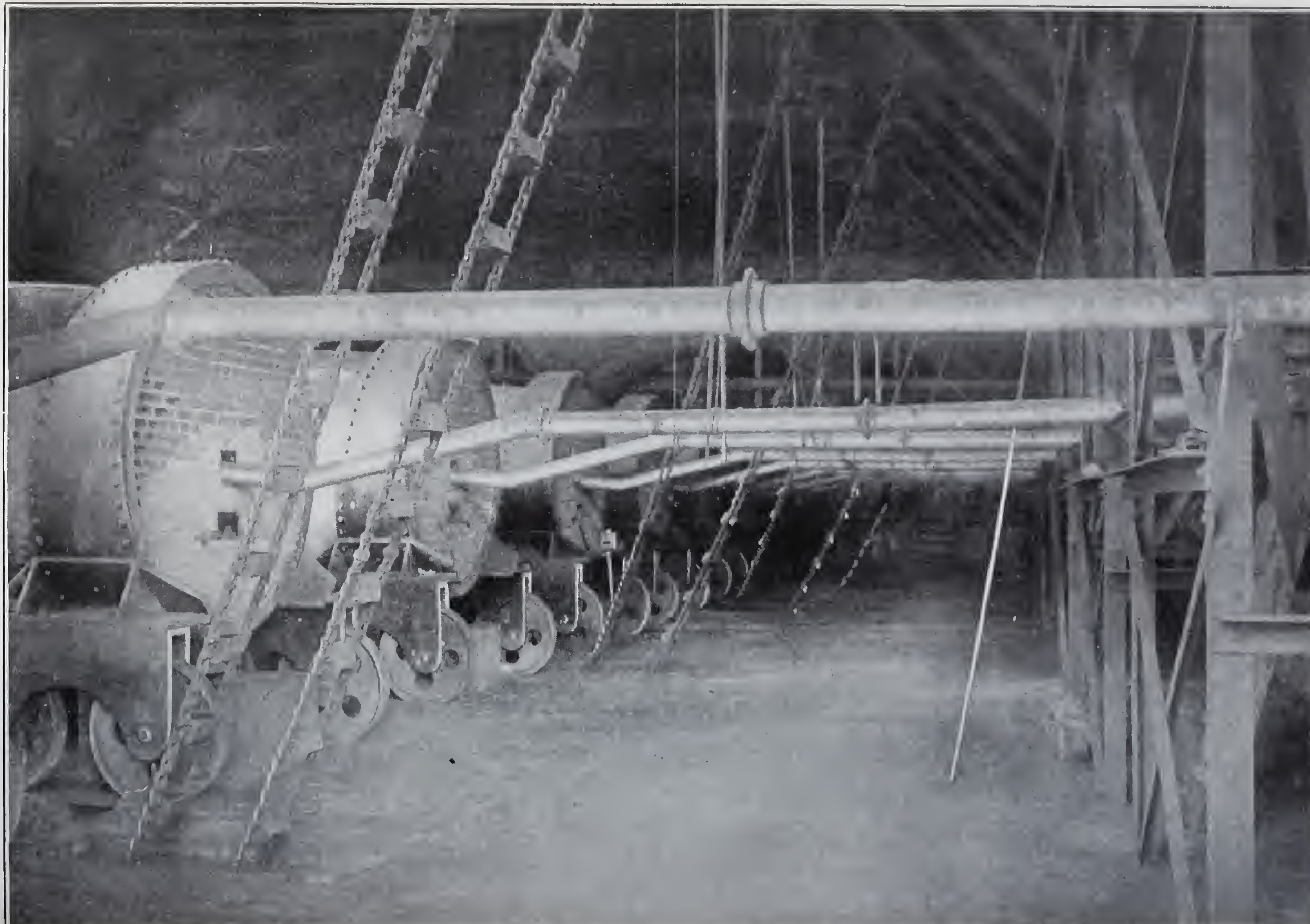

Fig. 12.—Battery of Rotary Kilns—with Fuel Piping and Elevators for Handling Hot Clinker.

The grinding machinery differs little from the standard practice, ball- and tube-mills being installed in this instance. Griffin mills are also frequently used. The entire plant is electrically driven, twenty-six motors being installed, the tube-mills, ball-mills, and other large

Fig. 13.—Clinker Grinding Machinery—Ball-mills.

machines having individual motors which belt directly to the driving pulley of the machinery. The elevators, conveyors, etc., are all arranged in groups, and driven through countershafts to which the

motors are belted, General Electric current motors being used, varying in size from 15 to 100 horse-power. The power plant is equipped with four 200-horse-power Wickes vertical boilers, two 500-horse-power Russell engines, and two 300-kilowatt General Electric generators,

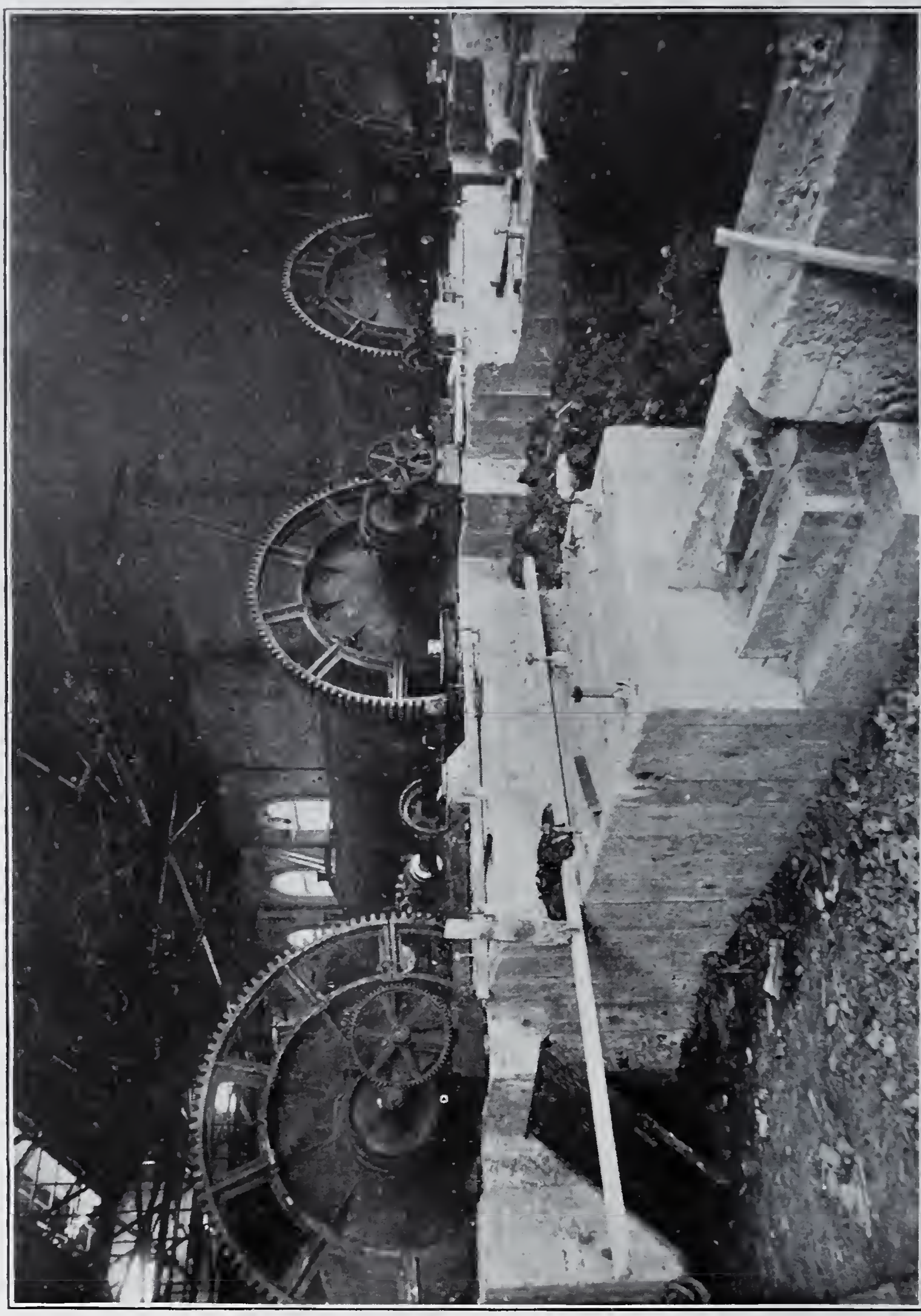

FIG. 14.—CLINKER GRINDING MACHINERY—TUBE-MILLS.

and it is contemplated in the near future to install an additional engine and generator, as the present generators and engines are loaded up to their limit, and there is no opportunity to shut off for repairs.

The plant was started in operation on October 1st, and cement was ready for shipment October 15th. The plant is at present only operating five kilns, as owing to a fire which destroyed the works of one of the subcontractors, the delivery of three kilns is delayed, and they are not yet ready for operation.

The buildings are non-combustible in construction: The raw material and kiln rooms are built of brick with steel roof trusses and corrugated iron roof; the balance of the buildings are of steel and corrugated iron.

Although advocates of the wet process are enthusiastic regarding the value of marl as a cement-making material, and in the Michigan district no other material can secure a hearing, and the same condition prevails in the Lehigh region in regard to the argillaceous limestone or cement rock, I notice a growing tendency to favor limestone and clay. The mills manufacturing from these materials are widely scattered, so the growth of this portion of the industry has attracted so little attention that there may be many who will question the statement that 22 per cent. of the cement manufactured in 1903 will be produced from this material. The use of limestone and clay is not confined to new enterprises, two of the largest manufacturers in the Lehigh region having erected mills in the West, and their estimated production for 1903 is 5000 barrels per day.

The following approximate table shows the amount of cement manufactured from the different materials in the past five years, and also the growth of the cement industry for that period, and I would not be surprised if the next few years show even greater gains for limestone and clay:

Date.	Argillaceous Limestone.		Marl.		Limestone.		Total.
	Production.	Per Cent.	Production.	Per Cent.	Production.	Per Cent.	Production.
1899	4,100,000	73	1,200,000	21	300,000	5	5,600,000
1901	8,700,000	70	2,150,000	17	1,850,000	13	12,700,000
1903 (estimated)	11,600,000	61	3,200,000	17	4,200,000	22	19,000,000

Fig. 15.—Plant of the Detroit Portland Cement Co., Fenton, Mich.

THE HANDLING AND STORING OF IRON ORE.

CHARLES PIEZ.

Read January 3, 1903.

THE phenomenal growth of the iron and steel industry and its strong and steady progress are strikingly shown by the fact that the total production in 1870 was 3,623,585 tons; in 1880, 6,486,733 tons; in 1890, 16,264,478 tons; and in 1900, 29,508,730 tons, or an increase in three decades of 804.2 per cent.

This wonderful increase in production was attended by a still more wonderful decrease in the cost to the consumers, for in 1870 the average cost of the total product was $63.49; while in 1900, during an era of exceptional prosperity and high prices, the average cost of the total product was but $27.24, considerably less than one-half the price of thirty years ago. This phenomenal reduction in cost has been effected very largely by the saving of labor, as is evidenced by the fact that in the production of pig-iron alone the output per wage-earner employed was 264.7 tons in 1890 and 367.2 tons in 1900, an increase of 38 per cent. in ten years.

It is with one factor of this cost reduction that the paper this evening will concern itself.

The total iron ore production in the United States during 1901 was in round numbers 29,000,000 tons, and of this amount the Mesabi, Marquette, Menominee, Gogebic, and Vermilion Ranges produced 20,000,000. In other words, two-thirds of the domestic production is dependent upon Lake transportation to reach the furnaces. As the Lakes are closed four months out of every twelve, it becomes necessary to provide at least four months' storage at the furnaces or else at the receiving ports.

The requirements of the ore-carrying trade have developed a special type of steamer of large carrying capacity, designed only for cargo. The hatches are close together and extend almost entirely across the deck. They are of such width as to readily accommodate the various unloading devices used, and their spacing and size insure that almost the entire cargo is directly tributary to them.

The vessels are loaded at Two Harbors, Escanaba, Duluth, and other shipping ports, from piers similar in many respects to those employed along the coast for shipping coal. These piers all have large storage capacity, so that the cargo is practically ready in elevated bins when the vessel reaches her berth, and can be transferred to the holds by suitable chutes within a few hours.

With a relatively short haul, despatch in loading and unloading is the essential factor in the determination of the freight rate; and the reduction of this rate from $1.20 per ton in 1890 to 60 cents per ton in 1900 is evidence of a marked saving of time in both operations.

The problem of loading the vessels was readily solved by the use of a strengthened and enlarged coal pier; but the problem of rapid unloading was by no means so simple of solution. The most successful device for unloading coal, particularly bituminous coal, from vessels is a hoisting tower equipped with an automatic bucket. The digging ability of this bucket depends on its weight, the shape of the blades, and the penetrability of the material to be handled. As ordinarily constructed, the blades are hinged to fixed centers and when closing swing through arcs of circles. When fully open the lips are swung well back toward a horizontal line, so that the first movement of closing is an almost vertically downward one, very similar to that of a spade when used in digging. In fact, the older forms of automatic bucket are essentially digging buckets. Now, anthracite coal is sufficiently mobile and bituminous coal sufficiently penetrable to permit a digging bucket of either the clam-shell or orange-peel type of sufficient weight to readily enter and fill itself; but iron ore as a rule is so heavy, so immobile, and frequently contains so large a percentage of hard lumps that seem locked together, that the ordinary clam-shell bucket cannot be used with any degree of success on all the various grades of ore. Even the orange-peel bucket, which owing to the shape of its blades has considerably greater digging capacity than the ordinary clam-shell, is unsuccessful in the harder grades of ore.

It was largely on this account that up to a very few years ago automatic buckets were not considered feasible in the handling of ore, and the unloading from vessels was done wholly with tubs.

About twenty-two years ago the first Brown hoists, as they are familiarly called, were erected by Mr. Alexander E. Brown, of Cleveland, and during the next twenty years these machines were brought to a high state of efficiency. They served the combined purpose of

direct transfer from vessels to cars, transfer from vessels to storage, and reloading from storage to cars. While the development of high hoisting and trolley speeds produced really remarkable results in reducing the time taken per trip, the fact that the tubs had to be filled by hand and that the loads were relatively small militated seriously against large hourly capacities. Still the time for unloading vessels was materially reduced by nesting or grouping these machines so that ore could be taken from all hatches simultaneously. Fifty tons per hatch per hour was exceptional, but the employment of twelve bridges on one vessel enabled vessels of even 7000 tons to be unloaded within twelve hours. Even this remarkable record did not satisfy the demands of the times, and the inventor's genius was set at work to reduce both the time and the cost of unloading. This has now been accomplished, and it is to-day not unusual to clean up a hatch of 500 to 600 tons in four hours at a fraction of the old cost.

Among the methods devised for accomplishing this result, one by Mr. Mason, of the engineering firm of Hoover & Mason, and the other by Mr. Hulett, take prominence.

Mason accomplished the result by inventing an automatic bucket which fills itself in any grade of ore and by applying this bucket to a hoisting tower of the same general construction as is commonly used in the unloading of coal. The general features of the Hoover & Mason bucket are its great weight, its tremendous spread when open, and the peculiar movement of the blades when closing.

The buckets on the vessel unloaders have a capacity of five tons of ore and a spread when open of about 18 feet. The blades are flat in side view and rounded in section, resembling somewhat the blade of a gigantic shovel. The first motion of the blades on closing is downward to effect a partial penetration of the material; but during the early stages of the operation of closing the blades swing toward the horizontal, giving a scraping action for almost the entire reach. It is this scraping action that differentiates the Hoover & Mason bucket from the clam-shell and orange-peel bucket, and it is by virtue of this action, which gathers together the loose ore on the surface of the pile, that the bucket fills itself so successfully.

In the most recently constructed Lake vessels the hatches are 8 feet wide and 12 feet center, so that all the cargo is tributary to the hatches with practically no trimming. In the older class of vessels, however, the hatches are 24 feet center, so that after the

bucket has cleaned out the hatch a considerable mass of ore remains in the piles between the hatches. To bring this within reach of the hoisting bucket a scraper resembling a gigantic hoe weighing a ton or more is used. This scraper is operated by an engine located in the hoisting tower, and its movement backward and forward is controlled by a workman located inside the vessel. Often as much as a ton of ore is moved by this scraper toward the hatchway in a single stroke, and it is not unusual for the scraper to make five or even six strokes a minute. The direction of scraping is readily changed by shifting the guide and pull-back blocks through which the operating ropes pass.

Perhaps the most extensive and complete system of ore handling and storage ever installed is that constructed by the Hoover & Mason Co. for the Illinois Steel Company at South Chicago. It comprises every operation in handling ore at a furnace plant, from the unloading of vessels to the charging of the furnace stacks.

Fifteen self-moving ore unloaders or hoisting towers, mounted on gantry legs and equipped with five-ton automatic buckets, face the water-front, and these are so arranged that they will deliver either into cars or else into an immense trough of concrete which parallels the path of the unloaders. Immediately behind this concrete trough is the storage area, which is spanned by two massive bridges 518 feet over all. The water end of these bridges reaches across the concrete trough, while the land end overhangs the ore pockets. Each bridge is equipped with a ten-ton ore bucket, electrically operated, the entire mechanism being carried by the trolley carriage from which the bucket depends. The bridge bucket takes ore from the trough and delivers it into storage or else carries it directly to a transfer car running on top of the ore bins for distribution over the latter.

The bridges are so supported that, in addition to a parallel traverse, one end can be advanced ahead of the other as much as 300 feet. This is of decided advantage in reaching every portion of the storage area. Trolley speeds of 1000 feet per minute are attained, and this, too, with a trolley load, including bucket and ore, amounting very closely to 100,000 pounds.

The plant at South Chicago impresses one by its boldness and its magnitude, but in addition one is struck with the ingenuity and the carefulness with which details have been worked out. Everything is massive, and the guiding principle seems to have been to get capacity by handling large masses slowly.

The Hulett machine is built on radically different lines from the Hoover & Mason unloader. A very massive gantry, traveling on rails parallel to the wharf, supports a carriage which has a traverse at right angles to the face of the dock. This carriage in turn supports a tilting girder, at the water end of which hangs a ram carrying the clam-shell bucket. This bucket is rotatable in either direction around the axis of the ram, thus affording the opportunity to reach not only the ore that lies under the hatch opening, but also that portion which is filled up between the hatchways.

The ram carrying the bucket is always kept in a vertical position by means of a parallel motion device fixed to its head.

When unloading from vessels, the carriage carrying the tilting arm moves forward, bringing the ram over the hatchway. The arm is then tilted hydraulically, the ram descends into the vessel, and the bucket is brought into contact with the pile.

The bucket is of the clam-shell type, with its blades swung from the outer corners, so as to give it a wide reach. It is operated by a hydraulic cylinder, and in closing is aided by the unbalanced load of the tilting arm, insuring thereby a full load of ore.

The buckets on the unloaders in operation at Conneaut are of ten tons capacity, and are controlled by operators who are located on the rams immediately above the buckets, and who, therefore, descend into the vessel with them.

The purpose of the massive structure and the rather complicated mechanism seems to have been to insure full bucket loads when digging, by forcing the bucket into the material, and to provide means for rotating the bucket, so that practically the entire cargo becomes tributary to the unloader without the intervention of any scraping device.

The results are gained at the expense of moving many times the amount of ore handled for each round trip of the bucket. The end seems to justify the means, however, for there are a number of batteries of these machines in successful operation along the Lake front.

The problem of handling ore at the receiving ports, however, is only one step in the transit of the ore from the mines to the furnaces. Another problem is presented at inland furnaces, where storage on a large scale is absolutely essential to secure continuity of operation.

The closed season for navigation for furnaces depending upon Lake ore for the bulk of their supply makes it necessary for them to store at least 33 per cent. of their annual consumption; while the

additional amount required to safeguard them against strikes, interruption to traffic, and other contingencies makes it desirable to carry a storage of at least one-half the annual consumption. Even where continuous supply can be counted on, a storage of at least one-quarter of the annual consumption ought to be provided for.

The best location for the storage of ore is directly opposite the stock bins of the furnace, so that the machinery for handling the ore can deliver it into the bins with but one, or, if possible, no transfer.

This arrangement for more than two furnaces limits the length of the storage area for each furnace to the distance from center to center of the stacks. The average distance apart of the furnaces erected in new plants, like those of the Union Steel Company, Donora, and the Sharon Steel Company, at Sharon, is about 350 feet.

The greatest desirable height of pile governed by the design of the structure of the unloading machinery is about 50 feet, which gives an area of cross-section for the length of the pile of about 17,000 square feet, corresponding to about 1100 tons of storage.

Assuming the furnace to have a production of 500 tons of iron per day, corresponding to an ore consumption of about 875 tons in twenty-four hours, the storage capacity required, on a basis of one-half the annual consumption, is 16,000 tons; and this tonnage, on the basis of 1100 tons per foot of longitudinal section, could readily be obtained with a bridge having an ore storage space 200 feet wide.

For a plant having two or more large stacks and an ore consumption of 1600 tons and upward per day, a complete system of handling and storing the ore, limestone, and coke should comprise:

1. A line of stock bins with trestle approach; the stock bins to have capacity enough for several days' supply. The stock bin trestle should be designed to support one tower of the storage bridge.

2. A number of electrically operated weighing cars or larries arranged to receive the ore, coke, and limestone from the bins and deliver them to the furnace skip.

3. A dumping trestle running parallel to the bin trestle and connected to the yard tracks by an inclined approach. This trestle will support the other tower of the bridge, the bin trestle and dumping trestle being on opposite sides of the storage area.

4. A car dumper arranged to receive the loaded cars and unload them into self-dumping transfer cars for discharging into the bins or onto the trestle pile.

5. One or more electrically operated bridge tramways spanning the

storage area and equipped with automatic ore buckets; the buckets to take ore from the dumping trestle and deposit it onto the storage pile, or else to take the ore from storage and deliver into bins or transfer car.

Such a plant as above outlined involves, of course, a very large expenditure for installation, and is only warranted when very large quantities are handled daily.

For smaller plants the car dumper can be eliminated from the arrangement, and the span of the bridge tramway can be considerably reduced. There is no question, however, that even for smaller furnaces a series of stock bins, tributary to the skip hoists of the stack, through self-propelling larries, and an ore storage contiguous to the stock bins and served by a suitable bridge tramway, are essential factors in the earning capacity of the furnace.

For these smaller plants, where first cost is of paramount importance, short span bridges equipped with buckets of not more than three tons capacity seem to be the rational solution. The buckets are sufficiently large to fill themselves readily, and, with the light loads, materially higher hoisting and trolley speeds can be developed, resulting in fully as large a daily output as is attained by the heavy load, slow speed plan.

A characteristic plant for a single furnace is shown in the bridge tramway erected by the Dodge Coal Storage Company for the Penn Iron and Coal Company at Canal Dover, Ohio.

The bridge has a clear span of 140 feet, and has a cantilever extension at each end. It is equipped with a three-ton automatic bucket, the operation of the bucket, as well as the movement of the trolley and bridge, being effected by electric motors.

The bucket is arranged either to take ore from cars directly or from the pile under the dumping trestle, and deliver either into storage or into the stock bins.

At a large number of furnaces the old method of trestle storage is still adhered to, and at these plants some measure of economy in handling can be effected by using revolving locomotive cranes equipped with small capacity automatic ore buckets.

DISCUSSION.

The President.—The paper is now before the Club for discussion.

James Christie.—An interesting feature in connection with these large cantilevers is the way the foundations were made. Being placed near blast

furnaces where there was an abundant and almost continuous flow of molten slag, this slag was utilized for the foundations. Large trenches were excavated, extending the whole length of the structure, and these were filled with molten slag to the ground line. The concrete walls that support the traveling cantilever therefore rest upon immense monoliths of slag.

The President.—This is an interesting subject. It seems a wide gap when we look back forty years to the first improvements made in handling material such as coal, ore, sand, etc., by means of the Focht self-dumping bucket, patented about the year 1861, and which Mr. Piez has shown on the screen. The principle of this device remains the same to-day, but there have been such wonderful developments in its application, especially in adapting it to the unloading and handling of iron ore, that it has become a large factor in harbor work.

J. Chester Wilson.—I would like to ask, Mr. President, can those booms be operated separately, so as to operate over hatches at varying distances apart?

Mr. Piez.—Absolutely separately. Buckets are very rarely used for unloading from cars directly, but if the bucket is small enough, I presume fully 75 per cent. of the coal can be removed from the car. It is rather a slow operation. The bucket has to be very tenderly handled, because the least amount of sway brings it in contact with the sides of the car, and the bottom of the car is of such shape that the bucket catches and rips it up. The problems are confined more particularly to taking coal out of the holds of vessels and away from piles. In ordinary storage work we prefer to dump the coal into bins and make those bins so large that the bucket has enough room on all sides for clearance to enable the operator to handle them, and we can get high speeds as a result from that class of handling.

The President.—Two things struck me forcibly on the occasion of a visit to Cleveland, Ohio, a few years ago, in connection with the subject of unloading and handling ore and coal. One was the prodigious amount of work that apparently was performed by the men in working with the old-time self-dumping buckets. One example was a vessel of 2700 tons, which was unloaded in nine hours, using self-dumping buckets operated by Brown hoist cantilever machines. The rate of wages paid was ten cents a ton, and the men, I was told, averaged six dollars per day, to earn which they were obliged to handle about sixty tons of ore, in a working day of approximately nine hours. It will readily be understood that ore is not bulky.

Directly the opposite of this apparently superhuman effort was the ease and facility with which an eight-wheel ore car of 60,000 pounds capacity could be raised and rotated and the whole contents nicely dumped into six buckets or tubs, each of which, after the car had been again rotated and set back on the track without dislocating any part of the running gear, was picked up and the contents dumped or rather placed in the hold in such a way as to give no shock to the vessel, which was loaded without trimming and the cargo left in shape for the vessel to immediately steam out of the harbor. The time of vessels in the Lake trade is valuable, and they cannot spend hours in trimming cargo and cleaning up.

These, then, are the two operations—one in which man must exhaust his physical strength in filling a self-dumping bucket of a ton to a ton and a half capacity, a shovelful at a time, and the other, in which the car is picked up

and rotated and its load placed in the vessel by a machine operated by hydraulic power and controlled by a very few men without any apparent effort. This is certainly wonderful progress even in this utilitarian age, and the slides which Mr. Piez has just shown us illustrate what has been done within a comparatively few years in the economical handling of coarse freight.

Mr. Piez.—I want to say a few words more. The President's statement brought to my mind the result of about eight or nine months' work. We just secured an order for the first car dumper on the coast. The Delaware, Lackawanna, and Western have placed a contract for a car-dumping machine for anthracite coal. That is a very material departure from the old wooden piers used so generally at Port Richmond and Port Reading for loading anthracite coal. There has always been some feeling that anthracite coal had to be handled more tenderly—had to be wrapped up in tissue paper, as it were, instead of handling it as they do soft coal. The question of breaking up the lumps is quite as essential and it affects the price of bituminous coal quite as much as it does that of anthracite. We are interested pecuniarily and otherwise in the result of the first application of a car dumper to the anthracite coal trade.

Jas. Herbert Stitzer, Jr.—How do those car dumpers act? Could you tell us a little more in detail how they handle the car ?

Mr. Piez.—I was going to suggest that Mr. Johnston might give a little information on the subject.

A. C. Johnston.—I don't understand what is expected in answer to this question. The chief curiosity always seems to be regarding what becomes of the stresses in the car and cradle as they go over. It is rather difficult to describe without having slides. If we had those it would then be an easy matter. In the most successful dumper there are four counterweighted chains provided, and as the car goes over these chains wrap around the car. There are other forms in which the car has to be clamped by hydraulic cylinders. In the one just described by the President that is the form used. The chief objection is that if air should get in the pipes or anything interfere with the hydraulic system, the cars would be dumped off the machine. As a matter of fact, that has occurred several times. In the ordinary car dumper the car is first lifted up to the necessary height and the coal is delivered by means of a chute from the car to the hold of the vessel. In the Brown car dumper the coal is delivered into six buckets which are in turn picked up by two overhead cranes and their contents delivered into the boat, one at a time. In a still later form of car dumper the entire contents of the car are delivered into a large pan or receiving hopper, which is then raised to a sufficient height to allow the coal to be discharged by gravity into the vessel. Mr. Piez, in his paper, mentioned also another type first built in this country at Ashtabula. That consisted of a long tipping cantilever—something similar to the one described. The cars were brought up on an inclined girder, which was then tipped over, allowing the contents of the car to be shot out through the end. This required a special form of car, and as a matter of fact the Lake Shore Railway built something like sixteen hundred or two thousand cars especially for this machine. All the latest car dumpers will take any car in the whole train. To give an idea how easily the cars are handled, I may say that I have frequently seen practically a flat car with a twelve-inch plank around the edge, making the height of the sides

so low that the clamps would not descend sufficiently low to grip them. In order to handle such a car, lumps of coal are placed on the top of the twelve-inch plank and the clamps brought down on top of these. In every case the lump of coal remained uncrushed. On the other hand, the hydraulic clamps are so powerful that when they get on the top of the car and pull it down on to the machine, the truck, in going over, will not slip on the rails. The friction between the rails and the truck is sufficient to hold it even when its entire weight is thrust on the side. I think that is about all I can say in answer to that question, unless there is more information desired. There is nothing put on the car. In one form of car dumper the chain is wound around. The first action is to slide the car over sideways. There is no strain on the trucks whatever. In other machines, which have hydraulic clamps, these hold the car securely in every direction so that no sliding action of the car sideways is required. They are all steam hoist, and wire ropes are used for lifting the load.

ROCK ASPHALT AND ASPHALT MASTIC.

HENRY WIEDERHOLD.

Read January 31, 1903.

Mr. President and Members of The Engineers' Club and Visitors:

It affords me great pleasure to speak to you this evening—you, the representative architects and engineers of this city. The subject of my remarks is to be, as you are aware, "Asphalt"—more specifically "Rock Asphalt and Asphalt Mastic." (Asphalt in Greek, "Asphaltos"; in Latin, "Bitumen"; in German, "Erdpech.")

Asphalt was known in the oldest times and was used in the walls of Babylon, as Mr. Laird's book on the excavations in the Euphrates Valley and the ruins of Nineveh and Babylon has proved. Also, asphalt was used by the Egyptians instead of mortar.

The use of asphalt as a mortar is older than lime. Buildings of stone cemented together with asphalt mortar have stood for centuries. The bitumen of the asphalt has penetrated the stone, and it has withstood all climatic changes.

The use of asphalt as a binding material, or as a mortar, was lost in the Middle Ages, but in the year 1692, after the discovery of asphalt deposits in the Val de Travers (Canton Neuchâtel, Switzerland), it came again into use.

In the year 1712 a Greek doctor, by the name of Eirinis, who held a position under the city government of Berne, conceived the idea of using asphalt rock as a mortar or binding material, thus reviving the practice of the early ages, in which period asphalt was used likewise as a mortar.

To another use, also, asphalt was put in the early ages,—namely, to preserve valuable articles, which, without it, would have given way to the ravages of time. For instance, dead bodies were coated with asphalt, and reeds and other articles buried with the bodies were treated in the same way.

Quite a long time elapsed, however, before much use was made of asphalt. Only about 200 years ago asphalt began to come into use again in Switzerland and France in the construction of buildings, and mainly as a mortar.

Pliny in his book also mentions asphalt as a universal remedy for all possible diseases of man and beast, and verifies my statement that

asphalt has been used in the walls of Babylon. The writers Herodotus, Strabo, and Vitruvius also mention the use of asphalt in their writings.

However, it was only in the last century that asphalt came to be used generally—first in France, and from there it came to the general attention of the architects and builders in other countries.

In the beginning of this century the Seyssel mines, on the river Rhone, Department De l'Ain, were discovered, and from that point a new era begins for the use of asphalt. Up until then the making of asphalt mastic had been unknown. It first came into use in the year 1838, in Paris, when the first sidewalks were laid with the same. In the same year, in different places in Germany, experiments with asphalt were made, and wherever good materials were used, and the work properly executed, it always bore excellent results; but, unfortunately, poor materials and inexperienced workmanship soon gave asphalt a black eye, and it was looked on with suspicion by the architects and builders.

In the year 1860 the "Companie Generale des Asphaltes de France" acquired the Seyssel mines, and, under the able management of W. H. Delano and Leon Malo, the asphalt industries began to rise in France and Germany; and Professor E. Dietrich, of the King's Technical High School at Berlin, deserves great credit for the furthering of the use of asphalt for street paving.

The purest asphalt is found on the Dead Sea, in Venezuela, and the Island of Trinidad. The asphalt from the Dead Sea comes from the province of Syria, on its banks, and is sometimes found floating on the surface of the water. It is said that, in olden times, the fishermen used the so found asphalt for making their ships water-tight, and painting them with the heated fluid. This asphalt, on account of its brittleness, is of less value for street paving or waterproofing purposes.

Trinidad asphalt comes from the Island of Trinidad, one of the British Antilles, and from a lake in the southwestern portion of the island. It is by far the most remarkable and largest deposit of asphalt so far known. Its origin was unquestionably of a volcanic nature, of prehistoric times.

The asphalt found in Venezuela comes from the former State of Bermudez, now Sucre, and is likewise found in a lake. There are a few minor deposits of asphalt found in other portions of Venezuela, but the one mentioned is the largest and principal one.

Asphalt has also been found on the islands of Cuba and Barbadoes, and some of the other islands of the West Indies.

However, it is not my intention to-night to go into detail in regard to Trinidad or Bermudez Lake asphalt, and those specific kinds used in street paving, as the deposits of the Trinidad and Bermudez Lakes belong to the company with which I am connected, and it would plainly appear that I was speaking in the interests of our company, and wished to promulgate the qualities of the asphalt deposits in our possession.

The asphalt I wish to speak to you about to-night, and to which I call your attention, is rock asphalt; and my reason for wishing to speak to you on this subject is that too little of this, in my estimation, most valuable material in the building line is known.

There are very few reference books treating on asphalt, and especially asphalt mastic. I have often been asked in regard to such books, and again only within the last week, one of our prominent engineers requested me to furnish him with some pamphlet or books treating on asphalt or asphalt mastic, which I was unable to do. In view of all this, I thought it almost my duty to divulge what little knowledge my practical experience has taught me, and what knowledge I have gained from a course of reading covering everything that I could find on this subject. Most of the valuable points I have obtained from two books, one written by E. Dietrich, Professor of the King's Technical High School in Berlin, and the other by Ernst Nöthling, architect and Professor of the King's Technical High School in Deutsch Krone, in West Prussia. Unfortunately, both these books are only edited in the German language.

You all must admit that too often in your career has come the time when you were compelled to look around for some material which will waterproof your foundations for buildings or waterproof your bridges; material which will keep out dampness; material which will not easily disintegrate when in contact with water; material which will not be affected by climatic changes and which will stand the heat and cold without cracking; material which will protect your iron construction, no matter of what nature it may be; material which will meet requirements for sanitary floors; material for water-closets, kitchens, sub-basements, breweries, and, in fact, for any kind of floor where water is used to a great extent, and where floors have to be watertight. You all know, as well as I, that cement will not and cannot fill the bill. For the last twenty years I have tried, perhaps the same

as you,—you theoretically and I practically,—to solve this question; and I am free to admit that I have made many mistakes and have paid dearly for some of my experience; but, so far, nothing has appeared to me to come to fill the need in that particular line so well as asphalt mastic.

I am not speaking to you to-night especially for any one kind or another of mastic, which the company with which I hold a position imports or refines, and claiming that this is the only material to be used. No, gentlemen, I would not dare to come to such an intelligent body of men as I have the pleasure of speaking to to-night, with such an absurd assertion. I simply speak for asphalt mastic, no matter what company imports the rock and turns it into asphalt mastic ready for work, and no matter what mastic is brought to this country in a prepared state; any of it, so long as the material is pure and unadulterated, and is mixed by experienced men and laid by experienced labor, will fill the bill and do all that I claim it will do.

However, I cannot impress too strongly on you the importance that whenever you specify asphalt mastic, see that such be used.

In preparing the rock and making it into mastic, not alone in using the right rock which contains the proper bitumen, but also in the flux which is used to make the mastic, adulteration often takes place, and herein lies the danger. In this age of great competition too many imitations are used; too many cheap coal-tar substitutes, or mastic made out of still-bottoms or refuse of Trinidad or other asphalt, mixed with coal tar, or light oils are turned loose on the unsuspecting public as the genuine article.

To prove this my accusation, I could cite dozens of cases that have come to my knowledge during my business career; but nothing is gained by personalities. Just let me say to you, however, that in New York city alone our company sells hundreds of tons of still-bottoms or refuse of our refineries of asphalt to concerns who claim to be importers of asphalt rock and mastic, and who turn these still-bottoms or refuse of asphalt, by the help of mixing the same with light oils or cheap coal-tar products, into supposed mastic, and sell it to asphalt contractors.

In one of our largest Western cities, which I had occasion to visit a short time ago, I was successful in gaining admittance to the plant of the greatest Western concern of asphalt mastic. I did this in order to see what kind of rock they used, and, perhaps, whether I could learn something in the preparing of mastic. To my surprise, not a

piece of rock as large as the piece I hold in my hand could I find. Nothing but still-bottoms and cheap coal-tar products were the materials used to make "imported and genuine" asphalt mastic. Is it a wonder, then, that some of you gentlemen, as well as some of your fellow-architects and engineers in other cities, have found that the asphalt mastic which you or they had specified did not fill the bill?

But, gentlemen, to prove to you that deception in mastic is practised, not alone in this fair land of ours, but in other countries as well, let me cite three more circumstances which have come to my knowledge through my own personal experience.

While in the City of Mexico, some years ago, while laying the first asphalt pavement ever laid in that city, a party came to us with a sample of asphalt. Apparently it looked like the genuine article. We were told it came from somewhere on the Gulf of Mexico. On having it analyzed we were informed that the material in question had only 2 per cent. of bitumen, contained some light oil and a great deal of decayed vegetable matter. Nevertheless, the party who gave us the sample did not believe us, but formed a small company and started in business.

We saw one roof and two sidewalks, laid with this material, mixed with the help of coal tar, start to disintegrate and go to pieces in less than six months; and I am sure it did not stand its purpose for one or two years.

Only a few weeks ago, while on a visit to the Fatherland, I spoke of the merits of asphalt mastic to a cousin of mine, Mr. Julius Eubell, an architect and engineer of considerable renown and standing in my native city of Cassell, Germany. To my surprise, I found that he had lost his good opinion of asphalt mastic, expressed to me on former visits, and he frankly stated that of late years the roofs and waterproofing specified in some of his buildings had failed to give satisfaction. When I told him that we were laying roofs in America, never questioning their durability for from ten to twenty years, and that I could show him, in this City of Brotherly Love, roofs which had been laid for fifteen and twenty years without any repairs whatever, he almost seemed to disbelieve me. Quietly the next day I went to one of the prominent asphalt contractors, who I knew did a great deal of work in the asphalt mastic line, and a great deal of work in buildings designed by my cousin, and during a conversation with one of the members of the firm, he frankly admitted to me that

in this time of close competition they could hardly afford to lay the unadulterated mastic, and, in order to compete, they had to use the cheap flux, coal tar, to prepare their asphalt. Just think of it, gentlemen! This is done almost at the home of some of the mines of rock asphalt; the Limmer mines in Hanover being only about fifty miles from my native city.

On my way home I visited Paris. I examined the streets laid by our company in that city, and while walking along I noticed a gang of men repairing an adjoining rock asphalt street. By this I mean a street such as you have seen laid in our city here, and in other cities, of powdered rock, which is placed on the street in heated form and tamped down and rolled until a smooth and hard surface is obtained. I found that they were not repairing this street with the powdered rock and the same material that it had been laid with, but that asphalt mastic was being used. I was well aware that during the winter months rock asphalt could not be successfully used, on account of the cold, but still I wanted to get into conversation with the foreman who superintended the gang making the repairs, and find out their reasons. My knowledge of French is rather limited, but, fortunately for me, the foreman understood a little English, and with the help of my poor French and his poor English, and with a little of the language of the Fatherland thrown in, we managed to get along well enough to understand each other. He told me that during the winter months the authorities would not allow rock asphalt streets to be repaired with asphalt rock, but that they must use mastic. You can readily imagine that a street repaired with another kind of asphalt than originally laid does not present exactly a very pretty aspect. I inquired whether they were not compelled, as soon as the weather moderated and rock asphalt could be laid, to relay those patches with rock asphalt, and he quite innocently revealed to me that their asphalt mastic does not last longer than six months, and that they then have to repair the patches made now with asphalt rock. On examining the material in course of mixing in his pot, I had no occasion to doubt him. I took a sample of it from him and had it analyzed by our expert chemist, Mr. Clifford Richardson, and the analysis proved to be 7 per cent. bitumen, 14 per cent. of material passing 200-mesh screen, 79 per cent. of material passing 50- to 100-mesh screen, and nothing coarser than the material passing the 50-mesh, showing an entire absence of grit in the mastic. A mastic to stand street traffic, such as we are laying where it is to stand a great

deal of wear, ought to have not less than from 11 to 12 per cent. of bitumen; and, as bitumen is the life of any pavement, you can readily see the great deficiency in the mastic laid at Paris.

We have examined many mastics from Paris at our laboratory in the last two years, and find that most of them are adulterated with coal tar. The mineral matter in the mastic from Paris above referred to contained only 5.9 per cent. of material soluble in acid—that is to say, carbonate of lime. The remainder is a very fine white silicious sand common in the neighborhood of Paris.

Is it not surprising that no better mastic work should be done in the city of its birth and origin?

When I told the foreman that we have mastic in driveways and streets in our country which were laid five or six years ago and are yet in good condition, and that we had just laid a large thoroughfare through one of our largest department stores in New York city, which we have not the least doubt will last for years to come, he seemed to take it for a good joke, and in his pleasant Frenchy way smiled significantly.

I think I have sufficiently demonstrated to you that it is of the utmost importance that none but genuine asphalt rock, fluxed with pure bitumen, be used, and that under no circumstances should light oils or coal-tar products be used for this purpose.

When remelted and prepared for laying floors or waterproofing, again none but the genuine flux dare be used, and it must be mixed and laid by experienced men. If asphalt mastic work is done in this way, I assure you, gentlemen, that all I claim for this so far unequaled material can and will be fulfilled, and in a short time you will be so convinced of it that where one yard of mastic is specified by you now, thousands of yards will be specified.

Now, a few words, gentlemen, in regard to the different kinds of rock asphalt and where they may be found. Rock asphalt is found, as I said before, in Val Travers, or Val de Travers, in the Canton Neuchâtel, Switzerland; in Seyssel on the Rhone, in the French Department De l'Ain; in Lobsann, a little village of the north Alsace; at Limmer, a small town near the city of Hanover; at a small town Vorwohle, in Brunswick; and at Ragusa, on the south coast of Sicily. There are also a few smaller deposits on the Adriatic Sea, and in the neighborhood of Naples, but as none of these come to our market, I do not deem it necessary to consider them.

Natural deposits of rock asphalt had not been discovered until quite

recently in our own country, namely in the Indian Territory; but so far very little is known of that material, as no practical tests of the same have been made; hence I am in no position to talk intelligently to you of that particular material.

The rock asphalt of the above-mentioned different mines consists of about 70 to 85 per cent. of carbonate of lime, 8 to 15 per cent. of bitumen, a small proportion of oxide of iron, and a small proportion of carbonate of magnesia. While I have at my command and could give you the exact analysis of each of the different rocks mentioned, I shall refrain from doing so, as I wish to be fair with all rocks.

The proper and only way to prepare the asphalt mastic correctly—by this I mean the marketable article which is ready for shipment or use—is in the first place to have the rock, as it comes from the mines, picked and sorted; and to have those portions of the rock which are not thoroughly impregnated with bitumen thrown to one side. With a little experience and judgment this can easily be done. The rock is then, after being broken into pieces, either by machinery or hand, the size of about nut coal, thrown into a disintegrator and pulverized to a fine powder. In specially built melting tanks, with an indirect heat, and provided with continual agitation, the flux (neither light, volatile oils nor coal tar, but a flux of pure bitumen, refined from the best possible asphalts, Bermudez or Trinidad) is placed, in the right proportion; and, after being thoroughly heated and made perfectly fluid, the pulverized rock is added to the same. The kettle is now closed. and this mixture is left to cook for from four to six hours, at a heat of at least 250° to 300° F. An experienced eye knows when the mixture is ready to be drawn off into molds. These molds are either square, round, or octagon in shape, according to the manufacturer's trade-mark, and each one having a capacity of about 50 or 60 pounds of mastic.

After the so drawn off mastic is sufficiently cooled, and having been stamped with the name of its brand, it is taken from the molds and is now ready for shipment.

I cannot help but express that, in my estimation, it is by far the safer way to import the rock in its crude state to this country and manufacture the mastic here, rather than to buy the manufactured article, as in the latter instance you are more liable to buy a "cat in a bag," as adulteration can easily be practised on you by your European brethren. Especially have I been strengthened in this opinion since my last visit to Europe.

The so prepared asphalt mastic is now ready to be brought into use by the asphalt mastic operator, and now the judicious manipulating by the experienced workman begins. Placing the right amount of mastic, fluxing the same with the proper ingredients, adding the right amount of grit, and perhaps some sand, just as may be required by the proposed work, the material is left cooking, under continual stirring, and is ready for use whenever a wooden stick inserted in the mixture comes out perfectly clean, no material whatever adhering to it. It is then spread, with the help of wooden spatulas or floats, to the required thickness on the prepared foundation, and, after having cooled sufficiently, with the help of fine sand and sandstone, rubbed to a smooth surface.

By no means am I, or any one familiar with the mixing of the mastic, able to give you a uniform mixture to be used for all floors and waterproofing. The mixture depends entirely on what use the floor is to be put to, as it requires a different mixture for different purposes, and it is here that the experienced workman comes in.

Great care must be taken to ascertain what is required of the floor to be laid; whether it is to be used under or out of water; whether acids (if so, what kind) are to be used on the same; whether the room is to be kept cold or warm; and, in fact, only after taking everything into consideration can the mixture be decided upon.

An asphalt floor, by long odds, is more advantageous and will yield better results in cellars or ground floors where the moisture of the underlying ground may affect the floor. A cement or any other floor absorbs the moisture and takes a long time to dry if cleaned with water. To demonstrate this my assertion, I present to you here to-night a piece of cement pavement one foot square, which weighed, when perfectly dry, 20 pounds 12 ounces. Laid in water for a period of twenty-four hours and again weighed, it had absorbed 1 pound 8 ounces, making a total weight of 22 pounds 4 ounces.

Exactly the same thing was done with a piece of asphalt mastic flooring of the same size, and in twenty-four hours it had absorbed only 1½ ounces. This seems conclusive proof.

Another of the many advantages of the mastic floor is that you can lay it, if you use the right mastic, in a monolithic sheet, and no expansion cracks will appear. This does away with the expansion joints which must be provided for in cement, a great feature in sanitary floors, where microbes and germs of disease take root and thrive in those joints.

Some years ago, when we laid the biggest monolithic sheet of mastic ever attempted, in the lobby of the Pennsylvania Railroad station at Jersey City (this floor, by the way, is laid on plank and only one inch thick), some would-be wise men came and informed the engineer in charge that this floor would not remain six months before cracking; and it was only after the strongest persuasion on my part, and owing to the confidence which the engineer had in the experience of our company in this class of work, and the fact that we gave him an absolute guarantee for five years, that we were allowed to proceed with the work. This time has elapsed and no crack has been seen.

Last year, when the new great Macy building was under construction in the city of New York, in giving a bid I advised the architect to lay asphalt mastic in the sub-basement, instead of cement. I carried the day, I believe, more on the advantage which I claimed over cement—namely, that an asphalt mastic floor could be repaired during the night and used just as soon as the mastic had cooled off, whereas a cement floor takes days to mature. A floor of 95,000 square feet of asphalt mastic was laid in the said building, and I defy contradiction that there can be any better substitute for a sub-basement floor.

I could enumerate a great many more proofs of the superiority of mastic over the cement floors, but will not occupy your time this evening. However, allow me to say that it is often claimed that asphalt waterproofing on a vertical wall cannot be done. This is a mistake. It certainly requires more skill, and the cost is greater than when laid on a sloping side or a level floor, but it can be done. To prove my assertion I have brought a sample demonstrating to you how it can be accomplished. In order to give you practical proof that it has been done, just let me mention one of the many instances in my practical career.

Four or five years ago one of the handsomest churches in our city was in course of erection. One of our best builders in the city had the contract and one of the most prominent architects was the designer of the plans. As it was a Baptist church, a baptismal pool was necessary. On the specifications it called for the pool to be cemented ready for the marble lining. Our estimator had taken over the work and made his bid according to the specifications, calculating, along with the other work in our line, on only a cement lining of the pool. We were awarded the contract, and when it came to the finishing of the pool, seeing that the same was directly over rooms in the base-

ment, I called the contractor's attention to the work, and told him plainly that the pool built in that way would not be water-tight, as no pool lined with cement and marble could be expected to be so. On inspecting the specifications and talking the matter over with the contractor, he found himself in a quandary. In order to avoid any further trouble, and not to take chances, I offered that if he would furnish the carpenters and lumber to do the necessary framing our company would line the pool on top of the cement with asphalt and then the marble man could place his lining on the so prepared pool. This he readily agreed to, and after we had the pool lined with asphalt mastic, we ordered it filled with water and left it for twenty-four hours, and not the least leak was perceptible. The pool was then finished with the marble lining, as described in the specifications, and, to my knowledge, no leak has ever occurred in this pool up to the present time. I have prepared a small sample of how work of that kind can be done, and take pleasure in presenting the same to you this evening for inspection.

If you desire a floor that will stand extraordinarily hard usage, such as you might require in the racking-off room of a brewery, the baggage room of a railroad station, or the floor of a stable where the horses are to stand directly on the mastic, I would recommend the cast-iron frames, such as are used in the so-called "ironclad pavements," laid between two layers of mastic.

We have done a great deal of this work in fire-engine-house stables and fire-engine houses in New York city, and it has stood the test in a most excellent manner. In fact, the only wear on a floor of that kind is that of the top surface down to the iron stubs, when the floor can readily be heated and a new top layer laid on.

To give you a good idea of this particular floor, I have had prepared two of these special frames and part of them covered with the first coat of mastic and part with the top finish, showing you the exact mode of doing that particular kind of work.

I also take this opportunity of presenting to you to-night samples of asphalt rock in its crude state, as it is imported from the different mines; the powdered rock as it comes from the disintegrator; and furthermore, the rock as it is turned out in cakes by the different companies as asphalt mastic; also samples of bitumen, of refined Trinidad and Bermudez asphalt, and the best grit to be used in the mixture.

In lining reservoirs, whether built of stone, cement, or brick, it

is essential to paint the surface which is to be covered with asphalt mastic, first throughout with a specially prepared asphalt paint, which will unite the asphalt mastic to be laid against whatever material it may adjoin, and do it so thoroughly that it almost becomes a unit with that material.

To demonstrate to you how well this can be done, I submit to you this sample. I had two bricks laid closely in a wooden frame, painted the same with the specially prepared asphalt paint above referred to, and laid, as you see, one inch of mastic over the same. When sufficiently cold, I had these bricks laid on an anvil in such a position that the one brick extended over the sharp edge of the anvil. It was my intention to have this brick break in the joint, but to my own surprise the material had united so well that it did not separate in the joint, but, as you see, the joints are undisturbed, and the brick broke instead.

I do not wish to be misunderstood, however, in regard to waterproofing, and claim that water can be kept out of all buildings or foundations with the help of asphalt mastic. Waterproofing with asphalt mastic can only be successfully done when the pressure of the water is not too great. If you can, either by pumping or other device, take the pressure of the water away until the concrete foundation is laid, on which you will lay a layer of mastic in two layers lapping the joints, then again by laying the necessary thickness of concrete on the said layer of mastic, to overcome the pressure of water from underneath, you will be able to make a waterproof job. I have also a sample illustrating how this work can be accomplished.

I hope, Mr. President and gentlemen, that my few remarks have been of some interest to you, and that they have proved to you that asphalt mastic is a great factor in the building line. If I have failed to be clear enough for any one of you, or if there are any doubts about any of my statements made here to-night, I shall be very glad to give further explanation to any one desiring the same. Hoping to have the pleasure of meeting and showing you through our mastic works at Long Island City, N. Y., as many of you as can make it convenient, on your proposed trip to the city of Gotham, on February 7th, and thanking you for your very kind attention, I herewith close my remarks.

DISCUSSION.

The President.*—Mr. Wiederhold has spoken of some distinguished gentlemen who are present. It will give us pleasure if Director Haddock will say a few words to us.

Director Haddock.—Gentlemen of The Engineers' Club: While listening to Mr. Wiederhold and looking at his section showing the lining for a reservoir, it occurred to me that if the opportunity offered I might compare his sample with the specifications that were prepared for the reservoir at Belmont. If I had a piece of chalk probably I could illustrate it. We have not specified brick for a lining because of the economy in doing away with it. We would have had to lay the brick on the floor and slopes upon a concrete base. We have done away with the brick to save the expense, and propose laying the Neuchâtel asphalt upon the concrete base. The specifications for tamping provide for the roughing of the surface, so that when the concrete is tamped it will leave the surface rough and form a bond for the asphalt. Mr. Wiederhold has called attention to the covering of the concrete with cementing material of some kind. I can't recall whether we have so specified. In our design we have brought the Neuchâtel up to within five feet of the water-line, the water-line probably being three feet below the top of the embankment. After bringing it up to within five feet of the water-line we turned it in and formed a bond with the concrete. It is two feet from this point to that (blackboard). We fill that portion with ballast trap rock. Our idea is that with the cement finish the concrete here will be sufficiently strong to overcome any inclination to leakage, there being but five feet of head. And we save the expense of laying the Neuchâtel asphalt. The wave washing, due to the wind and the ice that may blow against the side of the reservoir, causes a great deal of trouble and damage. The danger is eliminated because upon those two feet of broken trap rock is laid a pavement of Belgian block with the joints open. The water percolates through the Belgian block and drains back into the reservoir. We have a great deal of confidence in this idea and hope that there will not be a leaky reservoir at Belmont. Asphalt was used in the relining of the Queen Lane reservoir and there has been no trouble since. It was also used at Upper Roxboro, but I notice there an inclination to creep and run down the side of the slopes. I thought I would take this opportunity of illustrating the method of construction of Belmont reservoir, thinking it would be of interest to your members.

The President.—Will Mr. Webster occupy the floor?

George S. Webster.—The city frequently uses asphalt mastics for waterproofing the floors of bridges and similar structures. An illustration of the use of mastic may be noted in the floors of the upper decks of the recreation piers at the foot of Chestnut and Race Streets, where the floor was constructed by first placing a layer of cement concrete directly upon the metal deck, of a thickness of three to five inches, in order to give a proper slope for drainage. Upon this concrete was placed a layer of rock asphalt mastic one inch thick at Chestnut Street and one-half inch thick at Race Street, similar to the sample here ex-

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* Vice-President Silas G. Comfort in the chair.

hibited, and upon this the final granolithic wearing surface was depositde. These piers have been in use three or four years, and the water-proofing has been very satisfactory.

The metal decks of the bridges over the Pennsylvania Avenue Subway were covered with bituminous concrete, for the purpose of water-proofing, and the work has been very successful.

It was particularly important that these bridges should be water-tight, inasmuch as wooden sheathing was fastened to the under side to prevent the action of gases and the blasts of locomotives injuring the metal-work.

A good rock asphalt makes an excellent water-proofing and gives very satisfactory results in cases like Race Street and Chestnut Street piers. Experience has taught that the one-half-inch thickness used at Race Street pier is more economical and is sufficient to answer all purposes.

The President.—I take pleasure in requesting Chief Brooks to favor us.

William H. Brooks.—Mr. President, I don't know that I can add anything to what has been said. Of course, the question is more for buildings—that is, the demonstration and availability of asphalt—than it is the line I am engaged in; but my thought was that the speaker might give us some easy way of detecting, without going to a chemist, when adulterated material is given us. I thought I might pick up something that might be an advantage to me. I am very much interested in the discussion and have enjoyed it, and I think I have learned something.

The President.—I understand that we have with us Mr. Clifford Richardson, Director of the New York Testing Laboratory, Long Island City. Possibly he may be willing to divulge a secret and thus help the Chief.

Clifford Richardson.—It seems hardly possible to add anything to the history of asphalt mastic as given by Mr. Wiederhold. He has stated that no books have been published on the subject, but I am sure that when his paper is printed it will be an admirable source of reference.

All the materials that are used by him in preparing his mastic are examined and controlled under my direction in the New York Testing Laboratory. The mastic cakes are also subject to supervision there. The product of Mr. Wiederhold's company can, therefore, be relied on as being of standard quality and great uniformity. There is in this respect a great contrast between the mastic which is made by him and that which is used on the Continent and at times shipped to this country. When laying pavements in Paris two or three years ago I had occasion to take samples of numerous lots of mastic in use there, and have also had samples of this material sent to me by our agent there from time to time. Mr. Wiederhold has said that the competition there was so great that they have been obliged to resort to all sorts of materials to make the business profitable. I can well understand this, since, with but one exception, none of the samples which were collected and analyzed were free from coal tar. The result is that a very large percentage of the work done in Paris has to be renewed every year.

Where the adulteration of mastic with coal tar amounts to as much as 5 per cent. it can be readily detected by dropping some of the material on hot coals, when the odor of coal tar will be readily distinguishable. It is, therefore, not necessary to go to a chemist to detect this adulterant. The adulteration

by still-bottoms is more difficult to determine, and in that case the services of a chemist, skilled in work on these lines, will be necessary, but in the hands of such a person there can be no serious difficulty in detecting the falsification, owing to the presence of a larger proportion of silica in the mastic than would be possible were it derived from native rock alone.

Mr. Wiederhold has spoken of Indian Territory deposits. Owing to the heavy rates by rail from the West to the East, we can scarcely compete with the rates by water from abroad. Another difficulty is that most of the asphalt there is not in as large deposits as abroad, but rather in pockets, and no one pocket has been opened up yet which furnishes an adequate supply; so that at present we must adhere to the foreign rocks in our mastic. It may be that we can never compete with the American supply.

The President.—I understand we have with us Mr. Lober, and that, as the chair is informed, he ought to be able—is able (pardon me) to discuss asphalt with the best masters of the subject.

Wm. H. Lober.—The gentleman that made that suggestion knows that Mr. Lober's experience has been almost exclusively in street asphalt, and in the presence of such an expert master of the mastic branch as Mr. Wiederhold, he most certainly will not undertake to talk on the subject of asphalt mastic.

The President.—The flooring of the Jersey City terminal has been mentioned and in connection therewith Mr. Gardner's name. Mr. Gardner.

Martin L. Gardner.—All I can add to the remarks made by Mr. Wiederhold is that the work was done in the manner stated by him, and at the present time is very satisfactory. It is laid upon a plank floor studded with nails, and upon that was the inch of rock asphalt mentioned by him.

It has been laid since 1898 and is still in splendid condition, showing no cracks. I do not know that I can say anything more on that particular subject.

The President.—Mr. Trautwine.

John C. Trautwine.—Mr. Chairman, having had no experience either with rock asphalt or with asphalt mastic, the two materials discussed by Mr. Wiederhold, I am hardly in position to discuss his paper, further than to thank him for it, and to say that, after the meeting, I hope to obtain from him the names (which I missed as he read them) of the two authors on asphalt, mentioned by him. At Queen Lane and Roxboro reservoirs we used Bermudez and California liquid asphalts, but these hardly come within the scope of Mr. Wiederhold's title.

The President.—The chair does not possess the power of mind reading, therefore can hardly say which one is specially posted upon the subject of asphalt. We shall be glad to hear from any one who will favor us with any thoughts on the subject for general discussion.

Emile G. Perrot.—Mr. Wiederhold possibly remembers the reservoir built for the firm I represented about 1899, holding about 150,000 gallons of water. It was built of concrete and the retaining walls, I think, were about twelve feet deep and on the inside of the concrete walls and bottom was put a one-inch thickness of asphalt mastic, and upon that, I think, was put six inches of concrete to take up the pressure of the water and to keep the asphalt in place or from sliding, and I think that was surfaced again with a cement top coating about half an inch thick. The peculiar part was that it exemplifies what he

stated—absorption of water by concrete. When it was finished, it was filled up to a certain line and it was left overnight. The next day the owner came around and said: "That reservoir leaks; the water has gone down about six inches"; and our superintendent said: "We will look around to see where it went." It could not be found anywhere. We decided that the concrete must have been the place where the water went, so we concluded to let it alone and see what became of the water. Six inches was about as far as it ever lowered. The reservoir is still there, showing it did not leak at all. The concrete absorbed the water until the water struck the asphalt and stopped. The asphalt did the work of holding the water in a reservoir. If constructed without it, we would have had a continual leakage of the water. I think he remembers that case.

Mr. Wiederhold.—If you will permit me, I would like to go into details in regard to the construction of this particular reservoir. The reservoir was excavated, leaving an embankment on all sides. Against these sides we constructed first a concrete wall on all sides, which is called the "outer wall." We then laid bottom of concrete of the specified depth. On top of this we put a layer of asphalt mastic. We then built the inner concrete wall, leaving a space of $1\frac{1}{2}$ inches between this inner wall and the outer wall referred to. This $1\frac{1}{2}$-inch space was filled in with asphalt mastic, making joint with the asphalt mastic bottom, thereby making a perfect asphalt lining throughout the whole reservoir, bottom and sides as well. Then was laid the concrete floor covering the layer of mastic and the sides were plastered, giving the inner wall a smooth, finished surface, thus finishing the reservoir.

When we built this reservoir all sides were protected by banks of dirt, and we had, naturally, depended upon these banks of dirt to support our concrete walls. My surprise was very great when, a few weeks after having finished the reservoir, I noticed that the whole of the dirt on one side was removed, and this particular wall used as a side for an engine house, which was erected in the mean time. While I had great faith in our reservoir construction, I had not calculated on its being used for this purpose, and I think Mr. Ballinger stole a march on us. Nevertheless, I am pleased to say the reservoir stands to this day, not alone serving its original purpose, but also filling the bill as a side for an engine house.

Edwin Clark.—In the new building law of Atlantic City all new buildings of the first class situated on the ocean front that have not the regulated bulkheads are to be provided with curtain walls in the ground or basement story, the walls in the first, second, and above stories being carried on steel columns, the said columns to be protected with concrete six inches thick, then a layer of asphalt one inch thick, and this mass inclosed in additional concrete or brick. In the construction of the Merchants' Warehouse there was provided one inch of asphalt in concrete floor, which was about six feet thick, to stop the penetration of the water, the concrete floor being fifteen feet below low-water mark.

Mr. Trautwine.—The matter of the leaky reservoir mentioned reminded me of a bit of family history in regard to asphalt in general, which may be of interest to the Club. I understood Mr. Wiederhold to say that asphalt mastic would be water-proof, provided the water-pressure were not too great. At Queen Lane reservoir we were to have thirty feet. We had already decided

to use asphalt, when we came across a paper by Mr. Arthur L. Adams, of the waterworks of Astoria, Oregon, in which he made the statement that asphalt was not impervious, and that it would merely *delay* the passage of water through a structure lined with it. This, he said, could easily be determined by coating bricks with asphalt and putting them in water—almost as easily as in the experiment mentioned by Mr. Richardson. The bricks absorbed quite a considerable amount of water, though carefully covered all around with a good thickness of liquid Bermudez asphalt, and other experiments made seemed to confirm the statement, which was rather startling. Nevertheless we went ahead, and the Queen Lane reservoir was finished. About the time that the north basin was finished, the work on the Roxboro reservoir was nearing completion, and I invited the members of the Club to go out and see the work. Mr. Hand, General Superintendent, while taking counsel with me about this excursion, suggested also that on our way back from Roxboro, we stop off at Queen Lane and see the Queen Lane basin filled—a thing which was considered impossible. We arranged to get the south basin, at Queen Lane, filled by the morning of the day on which we were to go to Roxboro in the afternoon. Observations were taken, to see whether any leakage took place, and we stopped off there on our way back from Roxboro, as arranged. To our great delight the hook-gauge observations indicated that no leakage had occurred—if anything, a thousandth of an inch in depth had been gained. The next morning the basin was reported to be leaking, and a trip out there verified the report. We promptly drew the basin down to a depth of fifteen or twenty feet and held it there for some days or weeks, and then gradually filled it up again, and the basin has remained in working order ever since.

This fact has led me to the conclusion that, in placing asphalt over the cement concrete and clay linings of our reservoirs (the clay being of doubtful quality), we were simply placing a fine sieve over a coarser one, and that the sediment, carried by the water, most of which may have passed through the coarse interstices of the clay and the cement concrete, probably clogged the much finer pores of the asphalt, rendering the basins practically tight.

It may be, however, as has been suggested to me by Mr. Lober, that in suddenly loading the basin with its full depth of water, we simply squeezed out, from the underlying ground, the water, already stored in it, by rainfall or by leakage of the basin, etc.

James G. Davis.—As we are all invited to give our experiences with mastic asphalt, I wish to speak of it as to its serviceability for stable uses. Our Company—the United Gas and Improvement Company—have used it and are still using it almost exclusively in their stables, especially where they stable on the second floor. We have met with very great success. It was only by the use of asphalt mastic that we were able to get an absolutely tight floor. Our main stables are all of an expensive design and the best build, and of course it behooves us to put down the very best floor that we can get. My first experience with the asphalt mastic was with quite an inferior stable under the city at Twenty-fourth and Chestnut Streets. The stable there was on the second floor, which was built entirely of wood—carried on wooden beams. When this building was first adapted to stable uses, they endeavored to get the seams tight by the use of pitch cements and oakum, and in other ways. They were

not successful, however, until they used mastic asphalt as the covering surface for the entire floor, in which case it was used both for water-proofing and as a wearing surface, and I am glad to say that we had an absolutely tight floor just by applying the mastic directly on the floor boards. In two later buildings which are part iron and masonry, we covered the brick arches of the floors with a five-inch layer of concrete and then an inch thickness of mastic over that, and to satisfy ourselves that the floor was tight before we put the wearing surface down in brick, as a test we covered the entire floor with eight inches depth of water, equaling about forty tons. This was allowed to stand about forty-eight hours. Up to this time there has not shown one drop of leakage. It is the only way by which we find we can successfully water-proof our second floors and keep them tight for stable purposes. In one building we stable thirty-two horses, and in another we stable seventy-five horses, and as I say, up to this time we have had no trouble.

There is another line in which it might possibly be interesting to speak of the use of asphalt mastic. When the city's stable first mentioned caught fire in 1891, we assigned to the asphalt covering on the floor entirely, the saving of that portion of the stable below the second floor. If the fire had gotten below the second floor we would have lost nearly all of our rolling stock as well as a greater part of the building. It was due to the mastic floor, we think, that so much of the stable was saved, and consequently we saved about 50 per cent. of the cost of a new building. It seemed to confine the fire to the upper portion of the building.

Charles M. Burns.—Mr. President, I hope you will pardon an outsider asking a question. I think it would be a great satisfaction to some to have the term still-bottom explained more definitely.

Mr. Wiederhold.—Mr. President, I can readily explain to you what is meant by the term "still-bottom."

As you all know, the crude asphalt, whether Trinidad or Bermudez, is imported in large cargoes to our different plants throughout the country. In order to refine this crude asphalt it is placed in large steam stills, where, under continual steam agitation, all of the water is absorbed.

After it has been sufficiently agitated and boiled, so that all of the impurities will settle on the bottom of the stills, and the water is all evaporated, the pure refined asphalt is drawn off in barrels. The sediment remaining in the bottom of the stills, which contains a small percentage of bitumen, is termed "still-bottom." This sediment, or still-bottom, is removed from the stills and disposed of in the open market, in the manner previously described to you.

Mr. Burns.—Thank you very much, sir.

[In reply to various questions Mr. Clifford Richardson said *:]

Mr. Clifford Richardson.—Bitumen consists of a mixture of native hydrocarbons and their derivatives, which may be gaseous, liquid, a viscous liquid, or solid, but, if solid, melting more or less readily on the application of heat, and soluble in turpentine, chloroform, bisulphide of carbon, similar solvents, and in the malthas or heavy asphaltic oils. Natural gas, petroleum, maltha,

* Condensed from report of answers made by Mr. Richardson, during the inspection of the asphalt works, Long Island City, February 7th.

asphalt, grahamite, gilsonite, ozocerite, etc., are bitumens. Coal, lignite, wurtzilite, albertite, so-called indurated asphalts, the organic matter of bituminous shales and schists are not bitumen because they are not soluble to any extent in the usual solvents for bitumen, nor do they melt at comparatively low temperatures nor dissolve in heavy asphaltic oils. These substances, however, on destructive distillation give rise to products which are similar to natural bitumens, and they have been, on this account, defined by T. Sterry Hunt as "pyrobitumens," which differentiates them very plainly from the true bitumens. They usually contain oxygen, whereas the true bitumens in themselves do so to only a limited extent.

Asphalt is a form of native bitumen which occurs more or less pure, or mixed with inorganic or other adventitious non-bituminous matter. The name is also applied, commercially and in engineering parlance, to material in general containing this form of native bitumen or any form resembling it. The French apply the term "asphalte" to a bituminous calcareous rock, such as that of Val de Travers.

Asphalt is a solid at ordinary temperature, melts on the application of moderate heat, 100° C., is soluble to a large extent in petroleum naphtha, and entirely so in heavy petroleum oils, chloroform, and bisulphide of carbon. It yields about 15 per cent. of fixed carbon on ignition in the absence of air. It consists of a mixture of saturated and unsaturated hydrocarbons, together with small amounts of their sulphur and nitrogen derivatives. It is a product of the metamorphism of certain petroleums, the hydrocarbons of which are of a nature to be readily condensed under conditions occurring in nature.

Asphalt is made up of two classes of constituents,—those of a more oily nature soluble in light petroleum naphtha, often known as petrolenes, and those which are very hard and scarcely melt by themselves, and are insoluble in this solvent, but soluble in chloroform, known as asphaltenes, the hardness of any asphalt depending upon the relative proportions of these two materials which it contains.

Still-bottoms consist of mineral matter which settles out from asphalts, in the course of refining, in combination with the bitumen which cannot be separated and drawn off from this sediment. They contain, usually, about 16 per cent. of bitumen and are often utilized in making the cheaper grades of mastic.

Mastics are not made from American deposits of asphaltic limestone, at the present time, for two reasons: The deposits occur beyond the Mississippi, and generally at some distance from railroads. The cost of transporting them to points where they can be made into mastic is, therefore, too great. In addition, these bituminous limestones usually occur in pockets and are soon worked out, no large amounts being found at any one place, as is the case in Sicily, Germany, and France.

Artificial mastics do not compare favorably with those made from natural bituminous rock, since the limestone of the latter has become more thoroughly impregnated with the bitumen during the lapse of many centuries than can ever be the case with artificial mixtures.

The President.—If there is no further discussion, Mr. Gwilliam will make an announcement in regard to the proposed trip to New York. (Applause.)

Geo. T. Gwilliam.—Mr. President and Gentlemen: In connection with your

Information Committee we have arranged for the Club members and their friends to go to New York on Saturday next. We leave Broad Street Station on the 7.33 train. On arrival we shall be met by a delegation of New York engineers and go to Long Island City. After visiting the works of the Asphalt Company we shall go back to New York and have luncheon, then take in the subway. Mr. Parsons has very kindly consented to be with us and will send a delegation to pilot us through, and we expect to return in time for the regular meeting. We hope to have a good, big crowd with us, and all we ask is to send word that you are coming.

The President.—I think the explanation is eminently satisfactory.

Mr. Nichols.—In view of the very interesting paper we have had this evening, I move you that the Club tender a vote of thanks to Mr. Wiederhold for his presentation. (Motion seconded and carried.)

EXCURSION TO LONG ISLAND CITY AND NEW YORK SUBWAY.

February 7, 1903.

ACCEPTING the invitation of Mr. Wiederhold, Manager of the Vulcanite Paving Company, extended to the Club with the announcement of his paper, "Asphalt and Asphalt Mastic" (to be read at the conversational meeting), to visit the asphalt works at Long Island City, about two hundred and forty members of the Club and guests left Philadelphia on a special train at 7.33 A. M., Saturday, February 7th. The party was met at the Twenty-third Street Ferry, New York, by a reception committee representing the asphalt company, and was taken by cab and ferry to Long Island City.

The Vulcanite Company's works were first inspected thoroughly. Men were at work in one of the yards breaking up the piles of Ragusa, Seyssel, and Sicula rock asphalt with sledges and feeding it into the disintegrator. The melting house, where the furnaces were in full blast and the melting tanks in various stages of loading and cooking, was visited in relays. From one tank the mastic was being drawn off and poured into moulds, so that a very good idea of the process was obtained. In spite of the dust-laden atmosphere of the house, the party enjoyed this part of the visit, as evidenced by the number who secured samples of rock and small specially prepared souvenir blocks of mastic.

The Barber Company's works were next visited. Here were seen crude Trinidad Lake and Bermudez Lake asphalts in bins, and Mr. Wiederhold described the deposits and the method of removing the asphalt. Professor Clifford Richardson explained the process of refining, together with the apparatus used, and taking the party to the laboratories, there described the physical and chemical tests by which the uniformity of the finished products is maintained. Professor Richardson's interesting and highly instructive talk was much enjoyed and liberally applauded. At its conclusion the party was directed to return to the Thirty-fourth Street Ferry, New York, and reassemble at one o'clock at the Manhattan Hotel.

At the Hotel, as announced, a luncheon was found prepared, covers

having been laid for two hundred and fifty in the Banquet Hall. The luncheon proved to be an elaborate and enjoyable repast, over which Mr. Wiederhold presided. At its conclusion Vice-President Comfort rapped for order, explaining that our honored President, Edwin F. Smith, had been compelled to forego the pleasures of the trip, owing to ill health. Vice-President Foster proposed a vote of thanks to Mr. Wiederhold and his reception committee, for transportation to and across New York, their description of their works and processes, the luncheon, and other courtesies extended, which met with a most enthusiastic response upon being put by the chair. In reply, Mr. Wiederhold expressed his gratification that the members of the Club should have found the trip enjoyable and instructive, and his appreciation of the great interest shown. Further informal responses were made by Mr. James Christie and Mr. James Mapes Dodge, after which it was announced that the party would proceed to the Subway.

The visit to the Subway was started by a surface inspection of the open cut in the vicinity of the Forty-second Street Express Station, under the guidance of Mr. William Barclay Parsons and several of his assistants. Entering the partially completed Subway further north, the party proceeded through a practically completed section, emerging at the Sixtieth Street Station, where the party again collected for the purpose of officially extending to Mr. Parsons and his assistants in person the Club's appreciation of the courtesies shown by them to the party. Three cheers were given for Mr. Parsons.

After separation, a few members, specially interested in this class of work, returned with Mr. Parsons' assistant, Mr. Briggs, to Forty-second Street, where they entered the open cut and inspected it for several squares. His clear explanations of the many difficulties encountered and the methods employed to overcome them were very much appreciated.

The weather was ideal, and the day one long to be remembered as an incident in our Club history.

APPARATUS FOR AND METHODS OF TREATING WOOD, TO PROTECT IT FROM FIRE AND PRESERVE IT FROM DECAY.

JOSEPH L. FERRELL.

Read February 7, 1903.

Wood is a structural factor of vital importance. Its uses are infinite. It is the only material perpetually reproducible with slight care and expense from man. And this determines it as a permanent and essential factor impossible to eliminate. All inorganic substances have their limitations. Wood has perennial existence. So long as it is cherished and protected it will reproduce itself and forever be a boon to humanity.

Its peculiar adaptability as a structural component, its beauty, variety in texture and color, its susceptibility to mechanical manipulation, its ease of reproduction, all combine to make it dear to the heart of man. In spite of efforts to supplant it with other materials, its peculiar qualities will always render it a necessity to man.

The problem of wood protection, of converting it from a highly inflammable into an absolutely non-flammable product, has floated before the minds of generations of men rather as a vague, dreamy proposition than as subject-matter upon which to concentrate intense intellectual attention. Sporadic efforts void of practical utility are historically recorded at irregular epochs from Roman days to the present time.

So little is known by the general public of the practical results achieved in the line of protection of wood from fire that it is a tax upon its credulity to ask it to believe that the wood of a structure can simply, rapidly, and cheaply be rendered as uninflammable as brick or stone. It is even likely that such a statement may be questioned here and now.

It is not claimed that wood cannot ultimately be disintegrated and destroyed by attacking flame, as we know brick, stone, and steel may be; but it is claimed that wood may be so treated, and that the wood before you is so treated, that, upon the withdrawal of such flame, it

will not of itself, except perhaps momentarily, hold flame, whether in beam, board, or splinter. If this be literally or even measurably true, what is its significance?

Many years ago, in a great fire on Chestnut Street below Third Street in this city, the heat was so great as to disintegrate enormous masses of the granite walls. If wood is robbed of its inflammability, it is voided of its most serious objection in a structure.

If the wood in a building will not inflame from fire attack, but only slowly disintegrate, as other uninflammable materials will from contact with fire, then the contents of the building alone can be destroyed by fire in the building. Further, if the contents of a room inflame and the wood will not, then the fire can be localized, because the wood will not receive or transmit flame.

The elimination of the inflammable characteristic from wood is therefore a matter of vital consequence. And such treatment further as shall cause it to resist disintegration from fierce heat the greatest length of time, without at any time inflaming, must be the most desirable.

The sum of values arrived at, as a resultant of all recorded study, invention, and scientific deduction, up to the beginning of the present decade, as to protective treatment of wood, may be stated as—

1. Wood is susceptible of absorbing varied percentages of liquids.

2. That certain chemical solutions, when injected into the cellular structure of wood and afterward dried, leave a residual deposit of dry chemical therein, from which, with water, the solution was originally formed.

3. That such impregnation may be effected by pressure mechanically applied and by incidental processes.

4. That such deposit of chemical substance in the wood cells has in one case a preservative and in another a fire-resistant effect.

Practically, this formula condenses the whole state of the art up to a very recent period. The mechanical saturation of wood is really a new art. It found its first concrete development less than thirty years ago, in apparatus designed to saturate timbers with preservative solution. Previously abortive efforts had been made on a smaller scale, but were of no practical account.

Strangely enough, the preservative proposition claimed first attention; and as the work to be done required capital, capital called upon the engineer to formulate the apparatus with which to saturate the wood. The original theory of saturation, in its processional steps, is practised to-day with but slight modifications.

Fourteen preservative plants exist in this country, five in England, three in France, and five in Germany, as reported. All have the original typical apparatus and system of saturation, so far as can be ascertained.

The belief prevailed, and prevails, that the interfibrous and cellular system of wood contained elements denominated sap, which according to recognized authority was vicious, and generative of destructive fungus. No distinction seems to have been made between the *real sap,* the solid deposit, and the *sap water* which came to the tree heart, from the ground laden with vital power, performed its function, parted with its tree food, and failed to find its way as simple water into the atmosphere, only because the tree was cut down.

This *sap water* is very favorable to the propagation of germs, and is therefore really an undesirable element in wood. But the sap water is very small in amount in lumber cut for any time, and there is no reason whatever for any effort to eliminate it. For if the preservative solution is of any strength or value, it will impregnate such sap water and utterly destroy any germinative tendency. But the fact is that every effort is actually made to liquefy the *real sap,* the soul of the wood, and suck it out by vacual extraction.

The real bottom fact of the matter is that the original creator of the theory of saturation realized that, in sappy woods like yellow pines, the sap, being in such large volume, would resist saturation, and the only way he could see to get over the difficulty was to liquefy the sap by steaming, and exhaust it by the vacuum pump. Within the last two years a statement was made in a scientific journal, describing this process, that this result was so successfully accomplished as to "leave the wood in the condition of a finely divided honeycomb." Comment on such a statement is superfluous.

The steps of process by this original method of saturation are, after the cylinder is charged—

1. To introduce steam to liquefy the saps.

2. After prolonged steaming, to remove by vacuum pumps the substances so liquefied, the operation requiring many hours.

3. To fill the cylinder with the preservative solution, allowing it to impregnate the wood, so far as it will, by its own infiltrative action.

4. Then applying hydraulic pressure to complete the saturation.

This apparatus and process mark the first systematic effort to produce a commercial result in the saturation of wood, and it has been continued from the first until now, with immaterial changes, as the universally adopted type.

That the business of preservative saturation has not obtained universal acceptance may proceed from several causes:

1. The process of saturation occupies undue time, rarely taking less than from twenty-four to thirty hours for a charge.

2. Heart saturation in timbers of moderate square-section is incomplete.

3. It is believed that the strength of the wood is seriously impaired by the processional steps—steaming and exhaustion of the liquefied sap.

4. The chemicals put into the wood, being excessively dilute, are ineffective.

5. That the exposure to atmospheric influence causes them to volatilize.

6. That the cost for such a modified result is excessive.

At any rate, it is manifest that the growth of treatment of wood with preservative is sluggish, and not at all in proportion to the advance in price of such woods. It would seem that, if it were clearly demonstrated that ties, piles, and bridge timbers could be saturated at reasonable cost with a preservative which would treble or quadruple their average life when untreated, in a country like ours one hundred plants would scarcely suffice to meet the demand, instead of fourteen in thirty years.

The advance in cost of ties, owing to the great railroad development of the country and rapid exhaustion of the timber, has, however, induced a number of the Middle West and Western railroads to put in plants of the old type, to treat ties, and their growing use is evidence that it is found an economy, even with the crude apparatus and an expensive chemical.

Observation of the operation of the mechanism and processes employed, and a study of wood and its susceptibility to absorption of liquids, led to the conclusion that the desired results could be obtained by much simpler mechanism and an entire reversal of process. The old form of apparatus consisted of a cylinder of from 62 to 84 inches diameter and from 85 to 112 feet long, closed at one end, having a massive door at the other, swinging either horizontally or lifted vertically. This door is fastened by a multilocking system of bolts passing through lugs on the periphery of the cylinder.

It is obvious that an external joint of from 62 to 84 inches diameter which has to be opened, say, once or twice every twenty-four hours presents a practical difficulty of great significance when it is desired

to make it absolutely tight against any considerable pressure from within. If it leaks badly, no uniform pressure can be maintained. Further, perfect saturation, even of 1-inch-thick white pine boards, cannot be effected in any practicable time unless a pressure of at least 175 pounds is applied for several hours, no matter what preliminary process may have been employed. If a pressure of 175 pounds is put on the 84-inch gate area, it has been found impossible to maintain a tight joint and even pressure. If much leakage occurs, the pressure pump must make it up, and, in speeding up, its reciprocating shocks, delivered against wood whose exterior surface has been softened by previous steaming, exerts a most damaging and disastrous effect.

Therefore, the method of employment is to use, as that part of the process, a lower pressure, and avoid the rupture of the joint and damaging compression of the wood; but this is accomplished only at the cost of a great extension of time.

The new method wholly abandons all preliminary process. It was found from long practical testing that it was erroneous in principle, uncalled for, enormously expensive, and practically ineffective.

As stated in published descriptions, saturation of boards and plants by the old system required from twenty-four to forty hours.

The new mechanism is, instead of a cylindrical body of 84 inches diameter, 50 inches in diameter and 112 feet in length. The cylinder body is made up of cast-steel flanged sections, 2¼ inches thickness of metal, with a special hydraulic joint at the flanges capable of enduring a hydraulic pressure of 1000 pounds per square inch.

At each end is a domed gate, with a vertical hydraulic cylinder superimposed, which operates a vertical gate-valve weighing 5 tons. The gate is provided with phosphor-bronze rings, as also the inner and outer guide surfaces. When the internal operating pressure comes upon the gate, these ring surfaces coincide, and the joint is perfect, whether with 10 pounds or 1000 pounds pressure. The greater the pressure, the tighter the joint. In this case it is the reverse of the old externally applied gate.

Furthermore, all possibility of communicated shock from the pressure pump is obviated by the interposition of a hydraulic accumulator, loaded to the normal saturating pressure of each kind of wood. For white pine the normal saturating pressure is 300 pounds; yellow pine, 350 pounds; ash, 400 pounds; chestnut, 400 pounds; beech, birch, and maple, 450 pounds; oaks, 650 pounds; and the direct saturation

in this machine of 1 inch thickness of these woods can be performed under these pressures because of the absorption of shock from pressure pump, with perfect results to the wood, and in a small fraction of the time required by the old system.

The wood is simply taken as it comes from the source of supply, put in the cylinder, the gate is closed, the cylinder is run full of saturating liquor, pressure is applied, liquor is returned to the tanks, the lumber is run into dry kiln, and another charge of lumber is run into the cylinder.

The process is identical whether the wood is saturated with preservative or fire proofing solution—with this exception: The growth of experience demonstrated that the criticism of engineers regarding the non-permanence of the preservative solution hitherto injected into ties, piles, beams, etc., was a just criticism. It would seep out, slowly perhaps, but inevitably, under varying atmospheric conditions. For instance, several railroad companies having tie-treating plants believe that chloride of zinc most effectually acts as a fungus-destroyer. Chloride of zinc is an expensive chemical, costing from 5 to 6 cents per pound. Therefore, to be able to use it for their purpose, and not make their product too costly, they use a very dilute solution. In its dilute form the residual protective matter left in the wood is so slight that successive rains and evaporations in a relatively short time exhaust the infused material—wash it out. Practical investigation having positively confirmed this, it was believed that for wood exposed to weather conditions no treatment would be permanent except such a one as would create a chemical double decomposition in the interior of the wood. Three years of continuous investigation resulted in the production of an apparatus applicable to the treatment of railroad ties by a wholly new method. This consisted in saturating them *individually*, instead of in mass, which can be done with great speed and absolute thoroughness and uniformity.

The machine, with respect to its hydraulic gate, is similar to the large universal machine. It has, however, a gate at only one end, and is only a few inches longer than the tie; at the opposite end it is closed; but in that end there is a heavy cast-iron pad, in the center of which is inlaid a heavy rubber ring. This pad is attached to a hollow arm which passes through a stuffing-box at the back end. Back of the pad, a portion of the hollow arm is threaded, and this threaded section works through a fixed block correspondingly threaded, thus giving

a positive traverse forward and back of the rubber inlaid pad. A 3-foot wheel is keyed on to the outer end of this arm. Through the wheel a small pipe projects, which is connected with the supply line from the hydraulic accumulator.

The operation consists of raising the gate in front hydraulically. On the inside of this gate is another inlaid ring corresponding with the one on the pad at the other end. The tie is run into the machine; the gate is dropped. The wheel at the back head, being revolved, forces the *ring-inlaid pad* against the center of the tie, which sets it up in turn solidly against the inlaid rubber ring at the outer end in the gate.

It will thus be seen that the center of the tie at each end is set up solidly against a rubber joint. Now there is an opening in the gate opposite the center of the tie at that end, and an opening through pad in center of inlaid rubber ring at that end, through which liquor under pressure is supplied from the accumulator. If we leave the small valve in the gate opposite the center of the tie open and we admit the liquor under pressure into the center of the pad, that liquor will rapidly pass longitudinally through the tie and find its exit through the opening in the gate. If there is water in the wood, the water will come out ahead of the liquor, but will soon be exhausted, and the liquor of full strength will follow. If now we close the small valve in the gate and yet keep up the pressure on liquor entering the tie at the end, the natural traverse of the liquor is radial to its longitudinal axis, and it goes out through the medullary rays to the surface of the tie, evenly and thoroughly. Experience shows that this can be done, on an average, in seven minutes. If now we take another chemical solution and fill the cylinder with it, enveloping the whole superficies of the tie except the parts in the center of ends, and put a pressure on this liquor, it will saturate the tie compressionally and thoroughly, and the last chemical, mingling with the first, produces a chemical double decomposition, filling the cells of the wood with an insoluble substance which renders impossible the exit of the chemical from the wood, under any weather conditions. For instance, if, as the railroad officials assert, chloride of zinc is a good preservative, so long as it will stay in wood, and we use, as our first solution, sulphate of zinc costing one-third of the chloride, and afterward make the second external treatment with chloride of calcium at one-half cent a pound, we get as a resultant, *in the wood*, chloride of zinc, penned in forever by the nearly insoluble sulphate of calcium. Only in this

way can there be any absolute certainty that chemical solution will remain in wood subjected to atmospheric influences.

Full-sized machines have worked for months with all kinds of wood, and the rapidity of saturation by this end-treatment, along the sap lines, is wonderful. A battery of twenty machines costing $20,000 will turn out 1500 ties in a working day of twelve hours, or about 500,000 per annum, the cost of chemical being about 50 per cent. of the cost hitherto requisite, besides being permanently installed, instead of evanescent.

Each tie is treated separately, on the sap lines, and thoroughly throughout. This phase of saturation, being so revolutionary in its entire character, has induced me to be more prolix in its description than I could have desired, but it is surely worth its presentation to your attention.

The saturation of wood to make it *fire-resistant* differs in many respects from preservative treatment. Wood treated to make it fire-resistant is subjected to many stringent requirements not essential in the case of preservative. For instance, the saturation must be complete to the heart. The *color* of the original wood must not be impaired. The *strength of fiber* must be preserved. There must be no linger of flame on withdrawal of attacking flame. To effect this, the strength of solution must be as high as possible. This, of course, adds to the cost, and the density of solution requires greater pressure to infiltrate.

The "state of the art" at the time this work was begun embodied the employment of the original apparatus above described and processes therein exhibited.

This chemical, superficially studied, seemed to be all that could be desired. Wood saturated with it certainly would not *inflame*. Shavings planed from it would carry no flame. The treated wood would discolor more or less, but the refusal to carry flame seemed so admirable a result that such a defect seemed trifling. Longer acquaintance, however, destroyed the illusion. Familiarity bred contempt. Sulphate of ammonia is a whited sepulcher. It discolors wood. It effloresces and loses its virtue. It is hydroscopic and destroys paint and varnish. It decays wood inevitably. Its resistant virtue is excellent *while it lasts*, but its endurance against attacking flame is brief. For instance, if we stand vertically a piece of untreated 1-inch white pine before a horizontal Bunsen burner so that the blue point impinges, the average resistance to penetration and disintegra-

tion is thirty-two minutes. Similarly exposed, the average resistance of a piece of 1-inch white pine saturated with sulphate or phosphate of ammonia is sixty-three minutes, or an extension of life, due to the chemical, of thirty-one minutes.

Now, it is an admirable result to secure immunity from fire for thirty-one minutes, if no better result could be attained, and know that woodwork will not spread flame when treated; but it is not commensurate with the cost, and is not much to be proud of. Universally understood, it would not be considered a valuable commercial result.

The effectiveness of ammonia salts to repel flame from a wood surface depends upon the rapid volatilization of the ammoniacal gas. The greater the applied heat, the more rapid the exhaustion of the protective gas, and, when exhausted, no residual inert substance remains to bar the advance of flame or progress of disintegration. The gaseous emission chemicals were the only known materials used, up to five years ago, in any commercial fire-proofing plant.

It became necessary to seek for practicable materials, operating on a *reverse principle* from the gaseous emission, and after years of laborious effort sulphate of aluminum was discovered to be the substance endowed with the property of fire resistance inconceivably beyond any previous conception. For instance, the best results from the *gaseous emission* substances was an added life over untreated wood of thirty-one minutes. Now the average of 2800 pieces of 1-inch white pine treated with sulphate of aluminum has an added life of seven hours and thirty-eight minutes, or over fourteen times that of wood treated with the gaseous emission chemicals.

This most satisfactory result comes from the simple fact that sulphate of aluminum under flame loses its water of crystallization, its sulphuric acid of combination, and remains then *residual pure aluminum* which has the admirable property of expansion in the vacant cells of wood, to two and one-half or three times its original volume of dry sulphate; and in doing so it interposes between flame and wood fiber a compact mass of pure alumina, infusible by the flame of any conflagration, and an admirable non-conductor of heat.

It appears, therefore, that the fire resistance achieved in saturated wood proceeds from the *massing within it* of an inert and infusible substance, which from its non-conducting character *bars* destructive heat and produces endurance of the mass, and absolute negation to flame, for a prolonged period of time.

This, as the best result, seems to assure us that the *massing prin-*

ciple is the correct one; and it is further illustrated and confirmed by the extension of it in a wholly different application.

A casual remark was made over two years ago by a prominent insurance man, to the effect that the saturation of wood by sulphate of aluminum was assuredly a great gain to it in fire-resistant quality, but that *he* was quite as much, if not more, interested in the preservation of *existent* structures, from attack by fire, than he was in preparation for protection of non-existent structures, or those only in contemplation; and he counseled the serious study of this phase of wood treatment.

The proposition, in view of the small results accruing from the multitudinous so-called fire-proof paints, was by no means an encouraging one; but the powerful results accomplished on the *massing principle in* the cellular structure of wood bodies indicated the direction to be a *massing* of a series of chemical solutions on the external faces of wood bodies.

A wholly new set of phenomena appeared for consideration:

All paints known to the writer, applied to the superficies of wood, on the application of heat break up sooner or later, scale off, or otherwise disappear.

The attachment to the superficial cells of wood seems to be slight, and to effect a *bond* the *penetrative* effect of an initial application should be marked.

A chemical substance was discovered possessed of extraordinary penetrative power, a simple application entering even below the surface of oak one-quarter of an inch.

By subsequent coatings, other chemicals, *making chemical union* with the first, insured adhesion and condensation, and an *enamel, not a paint,* grew upon the wood surface, possessing a fire resistance over six times, on the average, that of wood treated by sulphate of ammonia solution diffused throughout the entire wood body.

The problem involved the discovery of a *transparent enamel* for hard and fine woods in interior work.

It compelled the discovery of means of application to woods covered with old paints and old varnish; the ability to absorb and receive on its surface lead or zinc paints when required; and it finally led to the discovery of means of incorporation of all shades of coloring in the massed enamel, so incorporated as to be proof against wear of weather exposure, and by such incorporation to preserve indefinitely the original freshness and brightness of the coloring-matter.

The palpable results of this work are before you. The aim has been

to honestly and most practically cover the whole ground of wood protection from the attacks of flame and fungus.

It is not for a moment claimed that wood treated by these processes is absolutely impervious to fire; that such wood is irreducible by fire; but it is believed that by these processes and chemical solutions wood has gained a large immunity from attacking flame, and that in each instance it will only disintegrate after the flame has persisted for such a great length of time that ample opportunity will be given for extraneous aid to extinguish it.

In going over the ground of results accomplished in the more effective protection of wood from fire, the vital value seems to be that its treatment produces unquestionable *non-inflammability.* It thus becomes a determined fact that wood thus treated, sustaining no flame itself, can communicate no flame; and attacking flame can endure only so long as its original fuel-supply remains unconsumed. Therefore, a fire originating in untreated contents of a structure will consume such untreated contents, and may blacken and roughen the surfaces of the structural wood, but can never excite any flame thereon if the fire resistance resulting from treatment is efficacious, and must necessarily be limited to the radial distance of the extension of the projected flame.

These facts are not only proved by minor tests, as those before you, but in the case of actual structures of treated and untreated wood of practical dimensions erected for comparative observation.

DISCUSSION.

L. Y. Schermerhorn.—I think the preservation of wood against decay would interest many members of the Club. I have had some experience in preserving timber by both creosoting and kyanizing. Their efficiency depends very much upon the wood being free from resinous oils. I would ask what effect your method of preparation would have upon Georgia pine, which is loaded with resinous matter.

Mr. Ferrell.—Georgia pine is the most difficult wood to effect a large saturation of, except white oak, that we have ever encountered. It is a timber we deal with here almost entirely. The actual sap—the condensed resinous matter—in Georgia pine forms such a large portion of the total volume of the wood mass in each instance, and it is so hard when the wood is dry, that it is almost impossible to penetrate it with any solution or any pressure that is safe to use on wood; but we are able, in fire-proofing Georgia pine, to fire-proof it just as well as we are able to fire-proof any other wood, because our solution, being a comparatively strong one and very penetrative as well, will go into the spaces

sufficiently to absolutely protect the resinous matters from contributing to flame. Now, that is a very curious thing. It was one of the greatest surprises I ever had when I attempted it. I did not ever make a perfect treatment, but I found that it lent itself to fire-proofing quite as well as any other wood. Now, as to the treatment for preservative purposes, I believe the solutions are usually weak. That is, you have no great strength of solution—five, six, or seven Beaumé seems to be considered ample. The railroads use, as I say, chloride of zinc, but they only use from five to eight Beaumé of chloride of zinc. Of course, that is very little more than the density of water and the saturation by pressure would be very easy to effect.

Mr. Schermerhorn.—What number of pounds of liquor on pine wood is efficient against decay?

Mr. Ferrell.—I am very glad you asked me that question. Here is an instance: If, by the ordinary method,—the method that has been used heretofore,—this wood should be saturated with a chemical for a preservative, you would have to use, say, thirty-five pounds to the cubic foot; you would have to use of these chemicals about twenty pounds to the cubic foot. That is, if you want to insure perfect saturation throughout. It is not only a question of getting perfect results, but where you use the compression method in contradistinction to the end treatment method, you have to put a great deal more material in the surface. When this material is trying to get in by surface treatment, you get a great deal more of the material here near the surface, and it grades slowly into the center. If you don't treat the center thoroughly, you get absolutely no efficient results; but if you use this other end method, you get all the material flowing along the sap lines. It shows itself right in this section of this tree. That was done by the end treatment method. That is absolutely perfectly saturated. It would be impossible, no matter whether you eliminate the saps of wood by heating or extraction, to thoroughly saturate wood as this is done by hydraulic compression, and the amount of material required for this perfect saturation throughout is only about 8 per cent. of the amount required by being put in by compression laterally. It shows its presence everywhere in this section. It is evenly divided throughout.

Charles Hewitt.—If the fire-proofing chemical should come in contact with oil, does the oil affect it—on a floor, for instance, where oil is continually spilled?

Mr. Ferrell.—No, I frequently saturate wood with coal oil and leave it saturated for twenty-four hours after the wood has been fire-proofed, but there is such rapid volatility of the oil when flame attacks the wood that it does not have any effect on the fire-proofing.

Mr. Hewitt.—I refer to a floor where oil is liable to drop.

Mr. Ferrell.—No, it will volatilize.

Mr. Hewitt.—It does not affect the fire-proofing?

Mr. Ferrell.—Not a particle.

Mr. Schermerhorn.—Could you give us any idea whatever of the cost of preserving white pine timber against decay per thousand feet board measure of twelve-inch timber?

Mr. Ferrell —Yes; you mean just in the form of treating, not in the form of beams, because that makes a great deal of difference; if I treat it in the form of boards it is different. I use, as I say, only 8 per cent. of the material by end treat-

ment in beams, and I get a much better result in beams than if treated compressionally,—say with 100 saturation,—whereas my saturations would run, if I had charged the wood endwise, only about 8 per cent. and a perfect saturation. There is no sense in using a very dilute solution, in end treatment. You have 8 per cent. of a strong solution there, and it is sufficient for all purposes of preservation. You have to satisfy yourself what is the best preservative solution. Choose your own solutions. Of course, we can go to work and use creosote in this way. The creosote is very volatile. We can charge a tie or anything else in that way in an incredibly short space of time. It seems impossible to have that material run through in three minutes, but we can do it, following it, with the other, seven to ten minutes, much more perfectly than it can possibly be done by the compression method, even if they liquefy the sap, as they say they do. It is the cost of the chemical and the labor. The cost of chemical in a beam—suppose you say you have a twenty-foot beam, twelve-inch square section, the *chemical* cost of that would only be about thirty-four cents.

S. E. Fairchild, Jr.—How much would the labor cost?

Mr. Ferrell.—That is dependent altogether upon whether you are doing it singly or whether you are making a commercial business of it. The labor cost is very small in that case. It simply means common labor. The machine that we would treat a beam twenty feet long in would be a machine exactly similar to that. (Exhibited in drawing.) That is only intended for a tie twelve to thirteen inches in diameter. This other would be like a machine that I have which would be thirty-five feet long, twenty inches in diameter. Now that machine will treat one of those pieces of lumber ten feet long in fifteen to twenty minutes. You see how many it would treat in the course of a day. Only enough labor is necessary to do that, because there is only one process—to run into the cylinder and out. The labor is nothing—common labor, nothing else. If you have enough to do to make a business of, say fifteen thousand feet board measure a day, your expense account outside of chemical would not be more than—well, say a thousand feet board measure would be about two and a half dollars, putting it into board measure.

J. Kay Little.—What per cent. would the cost of the machine add?

Mr. Ferrell.—A thousand feet board measure, treated in beam, would pay for your preservative and your cost account, provided you were doing a business of fifteen to twenty thousand feet a day.

Mr. Schermerhorn.—That is less than half the prices charged for creosoting timber, if the timber is creosoted to an extent of about fifteen pounds per cubic foot. The price usually increases one dollar a thousand feet board measure per pound added to the cubic foot. That would about double the rate which you name.

Mr. Ferrell.—Well, you must always consider this. This method of treating is very much more rapid than a method which in the first place requires to go through a steam and vacuum process. I don't know, so far as I can find out by reading pamphlets put out by these different companies, and from all other sources, I have not been able to find anywhere that they treat a charge of ties in a thirty-eight-inch cylinder eighteen to twenty feet long in less than eighteen to twenty hours. Now if that is so, it is a very expensive method. They keep a large force of men working for the different operations, whereas a battery of

these machines, using just as many as they want, will turn out three or four times that number with nothing but the cost of labor. You run your tie in and take it out. It is similar in a large machine. You run your beam in and put your pressure on the end. If a beam has a crack and it will not hold its pressure, or looks as though it would crack by the pressure going through, we fill around that beam and put the same pressure around it as through it. That acts as an hydrostatic band and enables us to do exactly what we want. The process is so simple that it is necessarily cheap.

Mr. Schermerhorn.—I understand that it is in the method and not in the creosoting of the timber.

Mr. Ferrell.—We would treat the wood with any material ordered in a cheaper way, because by the end saturation we use less of the material, and have it more thoroughly impregnated into the wood—more thoroughly than it possibly can be done by any other means. We have a great many samples sent to us treated compressionally where a portion of the periphery of the wood is very thoroughly treated and spotted at places to the center. It is very difficult to get to the center by compression method. I don't care what you put out, if you try to do it compressionally—I don't care what your preliminary treatments of heat or vacuum extraction are, wood will vary. Maple is different, white pine is different, and if you sample them, they are all different, and they take the materials you try to put in differently, except if you put them in longitudinally. We cannot do that with boards or planks. As a matter of course we can easily get it in them sideways. The great saving in chemical and the absolutely even distribution through the wood is the putting it in on its longitudinal axis in the case of beams. There is no question about that. That is my experience. It is very cheap and very thorough.

Eugene M. Nichols.—According to that plan, the best way would be to treat the logs before they are sawed up.

Mr. Ferrell.—That I used to think would be the best, but if you do that you throw away a very large amount of chemical. If you want to use the log without sawing it up, all right; but if you have to saw it up, you will throw away a large amount of the chemical which is in the sap wood sawed off.

Mr. Nichols.—Would not that be preferable to sawing up and then treating the boards, using the external method?

Mr. Ferrell.—Oh, no. There is one thing you could do if you located your plant at a saw mill; but the source of supply for fire-proofing are the lumber yards of a great city. The people who wish to use fire-proof wood are the inhabitants of great cities principally. People outside will have to be educated up to it. Now you have got to place your works to do this work near the lumber yards, where you can easily get the material into your works to treat, and where the delivery after it is treated is near at hand. It would be the best way if it could be done green at the mill—if it were practicable to do it that way; because the amount of saving in chemical, despite what there would be lost in the sap cuttings, would be very great; and the difficulties of compression method would be obviated—of putting the chemical into a piece of wood. When it is saturated by compression method all around, three-fourths of all the material that went into that piece of wood lies near the surface. Now you have got to get enough of the material forced in both ways to meet in the center, so that when

that wood is sawed up and used in plank, the part inside is perfectly treated, as it is on the outside—that is, to resist fire. Now, a much smaller portion certainly will protect that from fire. A saturation of 30 per cent. of this piece of wood, if I could get it 30 per cent. all the way through, would fire-proof that wood just as well as a saturation of 45 per cent. fire-proofs it. I have to saturate it 45 per cent. in order to make sure of getting my 30 per cent. in the center.

JOHN C. TRAUTWINE, JR.—Mr. Nichols's discussions always suggest interesting questions, and one of these has occurred to me in this connection, viz.: Will not the chemical treatment render the wood more difficult to treat—by sawing, planing, etc.?

MR. FERRELL.—No, not a particle. We don't use any chemical for fire-proofing that would interfere with sawing.

MR. TRAUTWINE.—What disposition could be made of the slabs sawed off from the outsides of the logs? Manifestly they could not be burned. Possibly they would have to be buried. Mr. Schermerhorn mentioned creosote as one of the chemicals used. Are not ammonium sulphates used also?

MR. FERRELL.—Those are for fire-proofing, not for preservatives. Ammonium sulphate was the original chemical used by the first people who started the fire-proofing of wood, and we all thought that it was a very wonderful thing until after a very considerable experience with it. We made the discovery first just as it shows here; in fact, it turned out worse here than I have ever seen it. *That* is a piece of untreated white pine. I put that there and put that Bunsen burner against it. That is a piece of ammonia-treated wood. Ordinarily the blue flame of the Bunsen will bore a hole through untreated pine in thirty-one or thirty-two minutes—disintegrate it and bore through it. Ordinarily the same Bunsen will bore through the piece treated with ammonium sulphate even if it is 150 or 170 per cent. saturation, in sixty-three minutes; therefore it is due to the chemical—the ammonium sulphate—with which the piece of wood has been treated, a credit of thirty-one or thirty-two minutes over an untreated piece of wood. Thirty-one or thirty-two minutes, or about 100 per cent. Here is a piece of wood treated with a solution of aluminum sulphate.

MR. TRAUTWINE.—In the process of rapid filtration, use is made both of alum and of aluminum sulphate. Would one of these answer as well as the other in Mr. Ferrell's process?

MR. FERRELL.—Yes. Now I'll tell you the difference. You know *alum* has been regarded as a great substance for fire-proofing, although it was really never tried for anything except fabrics for centuries.

SAMUEL P. SADTLER.—The Romans used it.

MR. FERRELL.—Very well. When I came to investigate the alum, I felt I had to get away from sulphate of ammonium. It adds very little additional life to wood attacked by flame. The best chemical to work with is sulphate of aluminum. We will saw that piece in two and show how little it is affected by the Bunsen burner. The life of that piece will probably be seventeen hours under exactly identical conditions as you now observe of the Bunsen flame against it. If you take the ordinary alums, not aluminum, and take, say, any quantity,—I don't care what it is,—and put it into a gallon of water and then test the strength of that, the utmost you can get out of that is five Beaumé—a very dilute solution. If you take sulphate of aluminum and put it into a

gallon of water,—take four and a half pounds of sulphate of aluminum to a gallon of cold water,—you will get from twenty-six to twenty-eight Beaumé strength from that amount. Now you cannot, with cold water, get any Beaumé strength from common alum; consequently you have got to heat your alum liquor to get strength. If you get the water to a boiling-point and put in eight pounds of ordinary alum, you will get sixteen, eighteen, and twenty Beaumé strength of liquor. Just the moment the heat goes down, down drops the alum and you have nothing more than five Beaumé.

Mr. Trautwine.—What is that difference owing to?

Mr. Ferrell.—Difference of solubility. There is nothing so cheap as sulphate of aluminum, and there is nothing so beneficial; there is nothing so easily handled. The great bugbear, no matter how it was prepared, was that it would discolor wood. Now, people are not satisfied. If I could make that piece of wood so that after it was bathed in fire for a month, of that intensity, and yet it would not be eaten up by the fire—disintegrated—people would say it was wonderful; but if in a fine house the light-colored woods were shaded to a brown or gray, and they lost their original color, why, they would not buy it, no matter how well it was fire-proofed. I have here some pieces of wood. That piece is treated with sulphate of aluminum. It was treated before the discovery of a method to maintain the original color of the wood. The change in the color was found to be objectionable.

I. Wendell Hubbard.—What percentage of weight is added after the material is saturated?

Mr. Ferrell.—Before it is dry?

Mr. Hubbard.—Yes, sir.

Mr. Ferrell.—A square foot of white pine, one inch thick, will weigh two and a quarter pounds if it is ordinarily dry. One hundred per cent. saturation would make four and a half pounds; 150 per cent., just that much more. One hundred is a very fair saturation in order to get into the heart as much as is required to do perfect work.

Mr. Nichols.—I would like to ask how much the life of such lumber as hemlock is prolonged by treatment. What has been your investigation? What have you found to be the life of that wood used as a railroad tie after treatment?

Mr. Ferrell.—We have had to rely upon such reports as we get from the government and from the few railroad people and engineers who would give us the results of their experience; and it has been a very difficult thing to get any recent and reliable data. I don't think that any treatment given to a railroad tie—that is, any treatment hitherto made of which I have any accurate information—will lengthen its life more than 30 per cent. on the average.

Mr. Nichols.—The reason that I asked that question was that eighteen or twenty years ago I was in charge of the Rock Island road between Chicago and LaSalle. I took out of track there ties that were cut half-way through. The foreman, who had been there from boyhood, told me that they had been in eighteen years. They were hemlock ties and very little decomposed.

Mr. Ferrell.—If they were lying in a place which was continually moist without getting dry, it might easily happen. It is rapid variation from excessive moisture to excessive dryness which produces very rapid decay in ties. If a tie is always in a very moist condition, it will last a great deal longer than when it is subject to great extremes.

Mr. Nichols.—This was ordinary gravel. I presume, during the fifteen years there had been a great deal of evaporation under the conditions where it was exposed.

Mr. Ferrell.—A United States government expert appointed to investigate this whole business has a plant located at St. Louis, and is going through the matter for the benefit of the railroad companies and for the United States government in a very practical way, and I presume through him we shall get the first reliable information that we ever have been able to get. If you look through the proceedings of the Engineers' Society of New York, you will find in their discussions a great deal about the treatment of ties, and the results that have been observed by the different men taking part in these discussions. You will be absolutely at a loss to arrive at an intelligent conclusion. One man's experience is contrary to that of another. So you cannot draw any inferences which are perfectly safe. There are certain chemical substances which seem to be agreed upon by professional chemists as having in themselves a perfect preservative value. Some of these substances are impracticable to use on account of their cost; others, for other reasons; but it seems to me there is only one way to get at this thing. The method of treatment does not make any difference to a railroad company. For instance, if I were to say to a railroad official, "We treat your ties. I will treat them rapidly. I will treat them thoroughly. My recommendation is to use such and such a chemical." He would not reply, "Oh, well, we don't believe in that chemical." Now, he does not care anything about the special experience of anybody; but if some one shows him such and such a chemical and says it would be a good thing, he would say, "All right, we will try it." If it did not produce a good result, it would be discarded.

Mr. Nichols.—I find creosote is all right, but it does not stand wear or decomposition so well.

Mr. Ferrell.—Creosote will not stay in hemlock. Creosote is too volatile. If you get Georgia pine, give it a good, thorough treatment with creosote, and can block that creosote in, you have a piece of wood that will last forever. But you cannot get it in. It is a substance that will evaporate. Like sulphate of ammonium, you may make the heaviest saturation, and in two years' time almost all is gone. The same way with the volatile creosote. It *will* get out. If it can be kept in, in my opinion it is most admirable; but it cannot be kept there in most woods, and yet it is an easy thing to get into wood. It is light and can be pressed in very easily.

Mr. Schermerhorn.—In your reference to the varied results obtained from preserving timber, I think that the reason perhaps lies somewhat deeper than the methods of application. There are all kinds of methods applied to the creosoting of timber, and, I think, as in everything else, its value depends largely upon the way in which it is done. To creosote timber so that it will be thoroughly preserved costs money. The user does not want to pay the cost. And the manufacturer will adopt a cheaper material, and the user is tempted to make the trial, and experience may demonstrate that it is a failure. I think that if any one should undertake, from published statements, to reach a conclusion as to the value of preserving timber from decay, he would have a mass of evidence from which he could reach no conclusion. Timber creosoted thoroughly

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will last, and a case in point exists at the Lewes Pier, Cape Henlopen. The government protected the pier referred to by fender piles, and secured a supply of Georgia pine that was creosoted thoroughly well by a very reliable firm. The fender piles, which have not been worn away by the vessels, are there to-day, and they are in as good condition as when placed thirty years ago. I examined these fender piles five or six years ago, and found them perfectly sound after twenty-five years' exposure; but the creosoting of that timber cost twenty-two dollars a thousand.

Mr. Nichols.—What did they do with the end sections?

Mr. Schermerhorn.—The timber was framed before it was creosoted. They were wise enough to do that. Now, at Oswego, N. Y., the old breakwater was built of kyanized timber. I saw it in '82. I was told that the breakwater had been built of hemlock timber forty years before. It was practically sound in '82.

Mr. Nichols.—What size beams?

Mr. Schermerhorn.—Twelve by twelve hemlock. I had a large quantity of timber creosoted for the new breakwater at Oswego. The timber was all framed before it was creosoted. It was creosoted up to twenty pounds per cubic foot. In some cases the creosote had nearly reached the heart of the timber—white pine. In other cases it simply penetrated an inch or inch and a half into the timber; so that while the average amount of creosote may have been twenty pounds per cubic foot, it probably varied between five and thirty-five pounds per cubic foot.

Mr. Ferrell.—If you will, take a look at this end-saturated sample, how evenly that follows around the lines. That is oak—the most difficult to impregnate of all woods.

Dr. Sadtler.—You were just talking about creosoting. I would like to say that a great deal depends upon the character of the creosote. Views on this subject have changed quite notably in recent years, and the railroads and others have changed the specifications for creosote within the last dozen years. A very full discussion is found in Lemge's "Coal Tar" as to the changed specifications in England. The specifications require a minimum percentage of naphthalene. Naphthalene is now considered to be a valuable addition. I have discussed this frequently with Dr. Jayne, and he tells me that the creosoting plants insist on definite amounts of naphthalene, and that seems to be regarded as a very valuable constituent. You will find that results will differ according to what are the specifications for creosoting liquid and what may have been used Creosote may be so robbed, practically, of the preservative elements that there is nothing in it of any value.

Mr. Ferrell.—A great point with any preservative, or any material which is used in a beam, is to get the material as evenly distributed in the heart as it is at the surface, if it can possibly be done. This cannot be done by the ordinary compression method; but whether you have a beam or log, it can be done by the other method. In fact, here the rings are wider apart the nearer you come to the surface, showing that that distribution is just in proportion, from the center to the surface, to the width of the other inch from the heart. A method which will do that strikes me as the method required. The more that can be gotten in the heart of a piece of wood, the more certainly it is going to stay, provided two chemicals are not used to make a double composition in the wood. The

following will probably be interesting to you: I have made the experiment of saturating the wood on the sap lines very thoroughly. The wood used was a large beam eight feet long and, I think, eight or nine inches square. It was weighed immediately after it was saturated, and then it was suspended from the ceiling of the room, where it remained for three days. At the end of that time there had dripped away over one-half of what was originally put in. That was simply by following the sap line. Now, all substances in the shape of a solution put into wood will seep out.

Dr. Sadtler.—What is that process which has sought to prevent its leaking out by putting glue in? The Wellman process?

Mr. Ferrell.—That is absolutely impossible. The Wellhouse process.

Dr. Sadtler.—That is it.

Mr. Trautwine.—Mr. Ferrell spoke of the application of the aluminum sulphate process to existing buildings. How would the application be made in that case?

Mr. Ferrell.—No, I have not been able to use the aluminum sulphate as a surface treatment. Here are three kinds of enamels. Now *these* are for the surface treatment of wood after a building is already erected. I have not succeeded, much to my regret, in making aluminum sulphate a feature of any one of these enamels. Sulphate of aluminum comes in for the *saturation* of wood; there it answers its purpose; but I have not been able to find a means of using it in any of these *enamels*. They are produced with other chemicals. This enamel works on the principle of successive coatings,—one following another,—and the following one making with the preceding one a chemical union and being a solid mass; that is, it is an enamel, not a paint. In that case it has resisted the Bunsen flame here two hours as against sixty-odd minutes of another piece of wood *heart-saturated*.

Mr. Trautwine.—I read recently a report by a committee of which Mr. Atkinson was Chairman, and my impression is that the committee found that the so-called fire-proof paints were not of much value.

Mr. Ferrell.—I have not found one of the forty-two or forty-three fire-proof paints (I have made as thorough examinations as I possibly could, in order to find out the best results attained) that would add fifteen minutes to the natural life of a piece of wood.

Mr. Trautwine.—I was going to ask whether the report of Mr. Atkinson's committee included other methods of treatment, and whether it condemned also such processes as Mr. Ferrell's.

Mr. Ferrell.—Well, he is in the first place unfamiliar with the use of sulphate of aluminum. If he condemned sulphate of ammonia, we could scarcely say anything, because any one can determine how much value in added life to a piece of wood sulphate of ammonia gives. (Method explained.) Practically, the life of that piece of aluminum-treated wood is fourteen times the life of that sulphate of ammonia piece and sulphate of ammonium is all that is known in this country outside of the new discovery of sulphate of aluminum as a fire-proof solution to saturate wood.

Robert Schmitz.—Have you made any experiments to show the effect of the saturation on the strength of wood?

Mr. Ferrell.—Yes; Professor Mason, of the University of New York, has

made comparative tests extending over a great number of pieces, and if I am correct, it showed rather a strengthening than a depreciation of the fiber.

Mr. Schermerhorn.—Your method does not involve the heating or steaming of the wood?

Mr. Ferrell.—Not at all.

Mr. Schermerhorn.—Creosoting of timber very surely injures its strength.

Mr. Ferrell.—I have always thought it did, but very recently I was reading an article in which it took an entirely opposite ground—that it had the opposite effect; but I am quite sure it depreciates the strength.

Mr. Schermerhorn.—It depends upon whether it is heated or steamed.

Mr. Ferrell.—It is utterly impossible to steam wood fiber without making it brittle. If you take the life out of fiber you take the strength. It is easily demonstrated. Take one piece of wood; saw it in two; steam one and don't steam the other; dry both thoroughly and make a physical test, and what the difference is in every case can be seen easily. Then, if you go to work, as thought best to do, and endeavor, out of the sappy wood, to steam it sufficiently to liquefy the saps already in the wood and extract them, and after it has been softened externally everywhere, and the vacuum pump applied to get all that sap out, then go to work and put all the pressure possible, consistent with the character of the construction of the cylinder, to squeeze it in, as a matter of course it must necessarily injure the wood.

Mr. Schermerhorn.—I am sure it would destroy the elasticity and transverse strength of the wood.

Mr. Ferrell.—After long experience I came to the conclusion that steaming of wood was wrong; evacuation of saps was wrong, whether the treatment of the wood was to fire-proof it or whether the wood was to be saturated with preservative solution. The method of pressure application is also of serious account, whether the pressure is moderate or heavy. If, when wood is in a bath of preservative or fire-proofing solution, the hydraulic pressure be applied directly from a reciprocating pressure pump, the hammer blow at every stroke will seriously affect the softened superficial fibrous layers of the compressed wood. Wood subjected to much greater pressures, where the hammer blows of the pumps are absorbed by hydraulic accumulator, shows on physical test no deterioration of strength. Occasionally wood so treated will show greater strength. By cylinder hydraulic process of saturation, soft woods, like white pine, in fifteen minutes, without any indirect preliminary processes, can be saturated 150 per cent. It has taken two years of testing to determine the average saturations of different woods. The saturation of new wood for new structures is, when in board or plank form, saturated by compressive method; if beams, by the end treatment on sap lines. Preservative treatment will be in large sections and all treated endwise.

The problem of fire protection in *finished structures*, in which the wood cannot be reached by the saturating methods, is solved by the superficial enamel method. Examples of this you see before you, where the flames of the Bunsen burners have been projected since 8.30 this evening (it is now 10.00 o'clock) against enameled wood surfaces. You see, I remove the burner and no flame adheres to the wood. The treatment is *cheap*, consisting of from two to three successive coats of different chemicals, and if you protect your structural woodwork every-

where with such coatings, it will endure an attack of flame of an intensity of 2462° F. for hours without receiving or imparting flame. You can apply it to floors or ceilings, or trim, or to any woodwork whatever.

The methods of fire-testing wood samples are principally by putting the wood on two stands *over* the Bunsen burner, or by standing the wood on end and projecting the flame horizontally *against* the face of the wood. The latter is the most severe.

I would be very glad to show any of you gentlemen the practical methods employed if you cared to call at the laboratory to see me.

A Member.—Is the factory open to visitors?

Mr. Ferrell.—We have a very large working laboratory here in Philadelphia, at 2220 Race Street, where all engineers are heartily welcome as any time. We have methods of keeping records there which are interesting, and a vast amount of information gathered together there that I guess is not equaled.

L. F. Rondinella.—I would move a vote of thanks to Mr. Ferrell for the very interesting demonstration he has made before us this evening. (Motion put and carried.)

COMMUNICATED DISCUSSION.

Carl Hering.—The subject of the preservation of wood and the elimination of the sap recalls something which came to my notice some time ago, but which I do not think is generally known, for if the method is as effective as is claimed, it ought to come into more general use, as it is so extremely simple. Its chief use was in connection with telegraph poles. The method consists in cutting the bark off the living tree for a short distance, completely around the tree, near the roots, the object being to completely sever the cellular connection through the bark from the bark on the tree to the bark around the roots. The tree will then live for a short time and will eventually die, and after it is dead it is ready to be cut down. The effect of this treatment is said to be that after this incision in the bark the function of the bark in supplying certain nutritive substances from the roots to the tree is stopped, and the result is that for a time the tree will live on the sap which is contained in the trunk itself,—that is, in the wood, —or perhaps only on certain ingredients in that sap; when these ingredients are all consumed, the tree dies. It is claimed that the ingredients which are thus consumed are those which ordinarily cause the timber to rot, and when they are eliminated while the tree is still alive, the timber is not nearly so apt to decay. Telegraph poles treated in this way are said to have lasted much longer than those made of timber cut down while the tree is alive, as is usually done.

Mr. Ferrell.—It has been my earnest purpose, in the specific range of investigation to which I have wholly devoted nine years of my life, to get at the bottom facts from practical experience. As regards the efficacy of *curing wood*, or perfectly seasoning it, by preliminarily "*girdling*" the tree near the root, and allowing it to stand until wholly dead, I made some experiments with old field pines, gum and poplar trees, in 1898, at "The Hummocks," Virginia, in woods on my own land, which thoroughly convinced me that *any of those varieties* of trees, so treated, were worthless for use (*if allowed to stand with the bark on*) for one month after the tree was "girdled."

The sustenance of the tree, supplied from the ground through the roots, and distributed by the natural forces to the extremities, is a liquid of identical Beaumé strength with water. By digestive processes the tree assimilates out of it the nutritive elements, parting with the valueless residual fluid by evaporative evolution. Now, so long as the tree is unharmed, the flow of nutritive fluid in season is constant. Cut through the bark, and the soft underlying layer between bark and solid sap-wood, and all channels of transmission are severed, all flow ceases. The amount of *undigested fluid* rapidly drains downward under the bark, and the mass of it runs away. That which is left, however, is positively determined to be the most favorable to the propagation of fungus germ of any known substance. (See experiments of Dr. von Schrenk at St. Louis, in charge of United States Government Experiment Station.)

The result is invariable, from my personal experience, that *the moment* a tree is girdled the fungus germ gets in its work in the damp and clammy area between bark and sap-wood, and, besides, *dead* bark attracts wood insects and borers to a much greater degree than living bark. On the other hand, those girdled trees which I decorticated, as I did in three instances, quickly—I think in about ten days—lost their sap-water, the surface dried off in the open air, and for a time—if I remember rightly, about two months—the surfaces remained smooth and in good condition. Then the process of drying produced vertical cracks in the line of the medullary rays, the gum first developing them, next the old field pine, and lastly the poplar, until at the end of an exposure of three months the wood was seamed all around with cracks, some of them one-fourth of an inch at the surface. The wood was dead—seasoned; but the atmospheric conditions placed, wherever the air entered the wood, the moisture carried by the air; and the germs carried by the moisture sought the inmost recesses of the wood, where moisture and darkness were constant; and these *stripped trees* invariably began to decay near the heart, whereas the unstripped trees began to decay between bark and sap-wood. At any rate, *none* of the trees, when cut down and split, or sawed, was free from symptoms of decay, and some of them were far advanced. They were all cut three months after girdling.

My experience inclines me to skepticism as to any efficient means of barring out the fungus germ, short of the introduction, into the cellular structure of wood, of solutions healthful to cellulose and inimical to germ life. As to the practicability of doing this, especially when the log is freshly cut, a perfect object-lesson will be furnished by me if any member or members of The Engineers' Club will advise me so that time be given to get the green wood. The ease and rapidity of doing this in green wood are remarkable. The drier the wood, the more difficult and the longer the time required.

THE "STATE OF THE ART" IN PATENT CASES.

H. BOVIE SCHERMERHORN.

Read March 7, 1903.

It has been suggested that a paper on a subject connected with the law of patents for inventions might be of interest to members of The Engineers' Club. The subject of patents and the patent law is not so far removed from the interests of the engineering profession as might at first thought be supposed. The patent solicitor must note and understand mechanical differences and resemblances as well as the legal effect of such differences and resemblances upon the case in hand, the patent law being a curious compound of law and mechanics, while on the other hand the engineer is frequently called upon to deal with the subject of patents and the patent law, if from no other standpoint, at least from that of an expert engaged to assist counsel in patent litigation. Most of the engineers present this evening have engaged in patent causes in this capacity as experts, and every engineer is likely to be called upon at some time in his professional experience to deal with the question of patents from this aspect at least.

Every engineer who has acted as an expert in this way has heard repeated in the course of the case one phrase more frequently than any other, and that phrase is "the state of the art," and he has recognized sooner or later that upon this phrase frequently depends the fate of the patent in suit. It is the meaning and scope of this technical expression, "the state of the art," and its effect upon patents for invention that I wish to explain this evening.

The expert can co-operate with counsel far more effectively if he knows, in a general way at least, to what end his testimony or his research tends, and what bearing it has upon the merits of the case in hand.

Our government, in granting a patent to an inventor, confers upon him a monopoly of the invention for seventeen years. As a return for this benefit conferred the government demands of the inventor two things: That the invention shall be *useful* and that it shall be

new. The degree of usefulness is immaterial provided the invention be in fact an operative device or apparatus. But on the score of novelty the demand of the government is absolute. Both to obtain a patent and to maintain it after grant it must possess novelty. Otherwise the condition fails upon which the government granted the monopoly and the monopoly is at an end.

Now, there may be novelty in two senses—novelty from the standpoint of the individual and novelty from the point of view of the world at large. An achievement in some branch of engineering might be a novelty to me while it was an old story to the engineering profession. The standpoint of the Patent Office and the patent law is the standpoint of the world at large. All they ask is, "Has this that the inventor claims to have done for the first time ever been accomplished before?" If it has, then it matters not that the inventor was totally ignorant of the prior achievement; his application will be rejected and his patent declared invalid.

The position sometimes taken by inventors in this regard is somewhat as follows: They say, when met by a prior patent covering the same ground with their invention, "I knew nothing of this prior patent at the time that I made my invention. I acted in good faith in perfecting my device and in entire ignorance of anything that had gone before me. Why, then, should I be refused the title of inventor because of a prior patent covering the same ground, but of which I was entirely unaware?" From the standpoint of the inventor this objection seems an entirely reasonable one, but the patent law upon this subject is not based upon the point of view of the inventor or the individual, but upon the point of view of the world and the community at large.

The patent law, realizing the impossibility of determining the good faith of an inventor in this respect, has taken the position that if the state of the art discloses the device, the new-comer cannot claim any title as inventor thereof. The object of the Patent Office is to issue as far as possible one patent for each invention and to avoid the overlapping of inventions or claims in patents issued by the office. Therefore the law broadly assumes the position that an inventor must take notice, as the expression is, of the state of the art, and it results from this that if a patent is inadvertently issued for something which is already embraced in the state of the art, that patent is liable to be invalidated in case this instance of prior publication or prior use, as the case may be, is brought forward against it.

In other words, it is the state of the art and not the inventor's claim, that is used as a standard of measurement by which to ascertain the true degree of novelty exhibited by his invention.

It will perhaps facilitate our view of this point if we briefly describe the process of obtaining a patent for invention in this country. The inventor, having perfected his device in what he considers its most complete and available form, applies for a patent thereon. In doing so he in effect says: "I have invented this apparatus or this improvement upon a pre-existing apparatus and I ask the government to protect me in my rights as an inventor by the grant of a patent."

The Patent Office, upon receiving his application, replies in effect: "You claim to be the original and sole inventor of this device or this improvement. Let us see whether you are or not." And the Patent Office thereupon proceeds through the examiner in charge of the case to point out to the applicant any instances of prior use, prior publication, or prior patent which may go to show that the inventor was mistaken in his idea that he was the first and original inventor of this device and that in point of fact the device is old and has been already patented or is already known and used.

The Patent Office examining staff is composed of about forty examiners, each having from four to six assistants. They have at their disposal a complete collection of all United States letters-patent issued since the institution of the office, and in addition foreign letters-patent and a large technical library of engineering periodicals similar to that possessed by the Franklin Institute in this city and the library of The Engineers' Club. Assisted by this collection of prior patents and of technical literature, the examiner in charge of the application points out to the inventor any instances of prior patent or prior publication going to show, as I have said, that the device has been already patented or already published and described.

The inventor thereupon proceeds to distinguish between his invention and the references cited against him, and thus by an alternate action between the inventor, or his attorney acting for him, and the examiner in charge of the application an understanding and agreement is reached as to just how much field the inventor is entitled to occupy in view of the state of the art.

For all this prior material, this mass of prior United States and foreign patents and of publications and technical literature pertaining to the subject-matter of the invention, constitutes as to that invention the state of the art.

Sometimes the reference in the shape of a prior patent cited by the examiner is, so to speak, on all fours with the device disclosed by the application. In such case, where it is impossible for the inventor to distinguish his device from the prior reference cited, the case ends then and there. Usually, however, this is not the case. The references cited by the examiner show that a portion of that field only which the inventor supposed he was solely entitled to occupy has been already preëmpted, but that a part of the field still remains open to him; and having, as I have said, reached an understanding as to just the extent of the field which the invention discloses, as to just the amount of inventive material embraced in the application, a patent for that amount of invention, neither more nor less, is sealed and issued to the inventor.

Now, we can explain this expression, "the state of the art," in another way. Let us suppose that this rectangle represents the sum of all the inventions that have gone to make up some piece of machinery which stands to-day in a highly finished form. Let us take, for example, the modern express locomotive. Let us suppose that the area covered by this rectangle represents the total number of inventions going to make up in the aggregate the express locomotive as it stands to-day. The largest single share or slice of this field was that preëmpted by the original inventor of the locomotive, Stevenson. As soon as men's minds were turned toward the possibilities involved in this new application of the expansive force of steam, inventions and improvements along this line followed one another with great rapidity, and the earlier inventions were doubtless of a very high degree of value and covered a field perhaps almost as large as that originally preëmpted by Stevenson, the pioneer inventor. Thus we can mark off successive sections of the total field and we notice that as we reach the end, and in proportion as we reach the end, the area remaining grows less, and we consequently find that to-day an invention in improvement of the locomotive does not go to the whole of the machine, but is a mere improvement upon some preëxisting and well-known part, efficient, useful, but not comparable in any wise to the extent and scope of the earlier inventions along this line. Now as to the inventors of to-day who wish to improve upon the locomotive, all this immense area stretching away back of them in the shape of prior patents, United States and foreign, that have already been granted for inventions and improvements upon the locomotive, constitute the state of the art, and each

new-comer's invention is to be measured by this state of the art extending behind him and its scope and extent determined by that state of the art.

In other words, if to the inventor of to-day the state of the art discloses anywhere in this prior mass of patents an instance of invention substantially equivalent and similar to his own, then he can no longer obtain a patent upon that improvement. If the prior art discloses only a portion of that which he has invented, then he is entitled to a patent for the remainder. It is thus apparent that upon the state of the art depends the question whether there is any invention at all in a given case, and if there be invention, how much invention is shown and may be patented.

We see then how important it becomes, both before applying for a patent and in many instances after the patent has been granted, to determine accurately the state of the art in that particular field of invention. If the inventor is to be fully protected, he must know just the extent of field covered by his invention and adequately claim that field in his patent. To know how much new field his invention covers, he must know to what extent the whole field has already been covered by prior invention, for it is only by placing, so to speak, his own achievement side by side with the sum of past achievements in the direction of his invention, that he can measure his own step in advance.

The strength of a patent depends upon the extent to which it fulfils two conditions:

First, the accurate determination of the degree of advance which the invention in question discloses beyond all previous inventions along that particular line; and,

Second, the framing by the inventor and allowance by the Patent Office of a specification and claims that shall accurately embody the precise degree of advance thus ascertained.

Given the first condition, a skilled patent solicitor can fulfil the second; but the second condition is dependent upon and valueless without the first. If the inventor and his solicitor have not before them all that has hitherto been done by others in the field of the particular invention, the utmost care and skill in framing the specification and claims, and in carrying the application through the Patent Office to issue, may be subsequently defeated by the results of a later and fuller investigation made by hostile interests, as in the case of a defense to a suit for infringement.

It is my present purpose to consider what a complete fulfilment of the first condition involves; what ground must be covered in its fulfilment; how far it is possible successfully to cover the ground; and to what extent this is accomplished by the various classes of searches or examinations made in connection with inventions and letters-patent.

This prior ground in connection with an invention is known technically as "the state of the art," and as all questions respecting the grant and validity of United States letters-patent are controlled and determined by the federal statutes at large, and the rules of the Patent Office made in accordance therewith, we must look to these laws and rules in the first place to ascertain what conditions they impose upon the inventor in this respect.

The statutes and rules provide:

1. That inventors shall take notice of the state of the art.
2. That inventors may not carry their date of discovery or invention more than two years back of the date of their application, no matter how much more than two years prior to application that date may in reality be.

This is equivalent to the statement that no patent shall be granted for a device if it be found that such a device was known or used at a date two years or more prior to the application for patent thereon, and that if an inventor on applying for a patent encounters such an instance of prior knowledge or use, he cannot, in his effort to show that he was the first inventor, carry his date of invention more than two years back of his date of application.

The reason for the first provision is obvious. When a device has once been used or described, it can no longer be considered new or novel in the sense in which the patent law uses those terms; and no subsequent use or description of it can constitute invention in the sense in which the patent law uses it. It matters not that the later inventor is acting in good faith and without the least knowledge of the prior discovery. The law charges him with notice of the prior discovery, whether as a matter of fact he knew or did not know of it. And a little consideration will show that however apparently unjust this may appear, it is the only equitable and practicable course.

The second provision—that relating to the two-year rule—is of recent date and arose in this way: Formerly, an inventor, having conceived his idea, could let it lie for five or ten years, or more, and then defeat a later and more diligent applicant by proving priority

of invention. Or an applicant, finding his progress through the Patent Office barred by a prior patent, might by forged affidavits and concocted proofs carry his date of invention back of the prior patent and thus secure the grant of a patent to himself. In a case with which I was connected a few years ago the application was filed in 1876; the patent was not issued until 1885, and the inventor, encountering certain references while passing through the Office, proved his date of invention as of 1866—ten years prior to his date of application. It was to do away with such unjust and possibly fraudulent practices that the two-year rule was enacted.

For the benefit of the inventor and those interested with him, it is therefore fundamentally essential to determine before applying for a patent,

1. Whether the application will be granted by the Patent Office.

2. Whether, if granted, the patent grant can be subsequently upheld.

After grant and issue of the patent, the same question may be put from another standpoint; *i. e.*, through prospective purchasers of or investors in the patent asking whether it is valid and can be protected against infringement in the event of a suit; and what scope in such case the courts will accord to its claims.

What ground must be covered in order to correctly and fully determine these questions—viz., the propriety of applying for a patent or the validity of one already granted? Broadly stated, we must determine the state of the art prior to the inventor's date of invention; that is to say, we must determine what instances, if any, there have been of prior use, prior patent, or prior publication of the invention, bearing in mind that an inventor cannot carry his date of invention at most more than two years back of his date of application for the purpose of avoiding such anticipation.

A search completely disclosing the state of the art must show:

(*a*) Whether the invention was known and used, in public use, or on sale in the United States at any date more than two years prior to the date at which the present inventor applied or purposes to apply for a patent.

This could only be ascertained by an inquiry extended throughout the United States among all parties engaged in the manufacture, sale, or use of similar articles or appliances. And to overlook a single clear instance of prior use is to overlook that which may be brought forward later to destroy the patent.

(*b*) Whether the invention has been described in any printed publication either in the United States or in any foreign country, at any date more than two years prior to the date at which the present inventor applied or purposes to apply for a patent.

This could only be ascertained by estimating the earliest date at which it is possible that such an invention could have been conceived, and instituting a search from this date down to within two years of the patent in question. This search would have to be extended through all printed matter, home and foreign, such as would be in any degree likely to contain the subject-matter sought.

(*c*) Whether the invention has been patented in any foreign patent-granting country at any date more than two years prior to the date at which the present inventor applied or purposes to apply for a patent.

This could only be ascertained by an examination of the printed and published patents of each country, from the earliest probable date at which such a patent might have been taken out down to within two years of the patent in question.

(*d*) Whether the invention has been patented in the United States at any date more than two years prior to the date at which the present inventor applied or purposes to apply for a patent.

This could only be ascertained by an examination of the United States patents as set out in the case of *c*.

In this connection it is essential to state briefly what amounts to or constitutes prior use or prior publication.

Prior Use: "To constitute a prior use the identical idea of means expressed in the present invention must have been reduced to practice and made available for immediate use. Neither a sketch of the projected art or instrument as the inventor has conceived it, nor drawings whether with or without verbal description, nor any model other than a practical and working instrument, nor even an application for a patent, can fulfil this requisite, since each or all of these can be produced without the existence of an operative and available invention." (Robinson on Patents.)

In Worstwick Mfg. Co. *vs.* Steiger (1883), 17 Fed. Rep., 250, the Court said: "It will be noticed that the claim of this patent is a combination claim consisting of several elements that co-operate together to produce the device claimed. This device, then, can only be anticipated by a prior device having identically the same elements, or the mechanical equivalents of those that are not used. It will not

do to find in older devices a portion of these elements in one machine, another in a second machine, another in a third, and so on, and then say that this device is anticipated."

In Gottfried *vs.* The Phillip Best Brewing Co. (1879), 5 Bann. and A. 4, the Court said: "It will be admitted that to justify the Court in overthrowing a patent granted for what appears to be a new and useful invention or improvement, on the ground that the device has been anticipated by another and earlier invention, the Court should be well satisfied by clear and credible testimony; that it was a perfected device, capable of practical use; that it was embodied in distinct form, and carried into operation as a complete thing, and was not of such a character as to entitle it only to be regarded as an unperfected or abandoned experiment."

Prior Publication: Such publication must be (1) a work of public character intended for general use; (2) within reach of the public; (3) published before the date of the later invention; (4) a description of the same complete and operative art or instrument; and (5) so precise and so particular that any person skilled in the art to which the invention belongs can construct and operate it without experiments and without further exercise of inventive skill. Unless a publication possesses all these characteristics it does not place the invention in the possession of the public, nor defeat the claim of its reinventor to a patent.

"The invention described in the publication must be identical in all respects with that whose novelty it contradicts. The same idea of means in the same stage of development as that which the inventor of the later has embodied, must be thereby communicated to the public. The invention thus described must also have been a complete and operative act or instrument, ready for immediate employment by the public. And it must be described not as a mere hypothesis, either in method or in possibility, but as an existing fact already known." (Robinson on Patents.)

The publication must not only be intended for the public, it must also have been placed within its reach. In other words, it must have been actually published in such a manner that any one who chooses and seeks may avail himself of the information it contains. It is not necessary that many copies of the work should have been printed, nor that its distribution should have been extensive; for the deposit of a single copy in a library to which the public has or can obtain admission places the work within the reach of all. Nor is it

requisite that any person should have read or seen it, since the accessibility of knowledge and not its actual possession is all that any inventor can secure. And even though the information be so intermingled with discussions relative to other subjects that it may easily escape attention and would require some skill and patience to extricate it, the publication will still be sufficient.

The foregoing explanations will serve to show in a general way what is meant by the terms "prior publication" and "prior use." It therefore amounts to this: That if the state of the art discloses anticipation in the shape of a prior use or a prior publication of the character above explained, and of such a date as the inventor cannot overcome, regard being had to the two-year rule, then such an application is inadvisable, and if application is, nevertheless, made and a patent is granted thereon, such patent is invalid.

Having stated the requirements of the law as to novelty and the manner in which those requirements are construed by the courts, it remains to consider what means we have for fulfilling those requirements by ascertaining the state of the art and consequently the degree of novelty exhibited by any particular invention.

To throw light upon the state of the art, recourse is had to searches. They are practically divisible into four classes:

1. The search made by the inventor or his attorney preliminary to application.

2. The search made by the Patent Office examiner in charge of the application during its progress to grant and issue.

3. The search made on behalf of prospective purchasers of or investors in the patent, after grant, to determine its strength and scope.

4. The search made by a defendant when sued for infringement and seeking to establish anticipation of the patent as his defense.

1. What the search prior to application covers: The first search usually made is by the inventor or his attorney prior to applying for a patent. It is rare for this search to be extended beyond prior United States patents along the particular subject-matter of the invention.

2. What the Patent Office search covers: The application appearing to be novel is filed in the Patent Office and thereupon the examiner in charge cites against it prior United States patents which he considers pertinent, also prior foreign patents and to some extent prior publications.

The United States patents are classified and arranged in accordance

with an elaborate system in such wise that the examiner in each department is supposed to have under his eye at the time that he is examining an application every prior United States patent already granted for the same or a similar subject-matter. Beside this mass of prior patents he places the applicant's device and determines the degree of patentability in accordance with this comparison.

It is somewhat unusual to have prior foreign patents cited against an application in our Patent Office, and still more unusual to have prior publications in technical and engineering journals cited against an application. I am told, however, that in electrical cases and other special classes of invention the citation of prior publication and prior foreign patents is very common.

It is proper in this place to refer to a very general misconception regarding the examination as to novelty which an application undergoes in passing through the Patent Office. There is a prevalent impression that an application is subjected to so thorough and exhaustive a scrutiny in its passage through the Office that its final grant and issue amount to a guarantee of its novelty, and that the patent is thereafter safe from attack. A little consideration will show how far this view is from the truth.

Suppose the examiner decides that a certain prior patent does not constitute an anticipation. This is necessarily only a matter of opinion, and his judgment may not be infallible. It happens by no means infrequently that the courts adjudge a patent invalid because of anticipation by a prior United States patent which the examiner possibly had before him and decided to be no bar to the application. It amounts, then, to this: that in granting a patent the Office merely says in effect: "In our opinion such prior patents as already exist along this line constitute no anticipation of your invention. This conclusion has been reached by a more or less qualified expert in this class of apparatus or devices, aided by a carefully classified list of all prior United States patents bearing upon the subject. But we do not and cannot guarantee to you the correctness of our conclusion."

Of course, the ability and skill of the examiners vary in the different divisions of the Office, and the average of ability is fairly high, but the inconclusiveness of their judgments is shown by the fact that out of all the United States patents subjected to the scrutiny of an infringement suit a large number are declared void by the courts because of anticipation by prior United States patents.

This is the second search made to determine the state of the art. Now should the patent issue and the inventor attempt to dispose of his invention to capitalists, those who undertake to put money into an invention for the purpose of exploiting it will rarely do so without making or having made an independent examination into the state of the art, in order to determine the value or validity of the patent.

Such a search, if made by a competent attorney, is usually of more value than either of the two searches preceding, for the reason that we have the advantage of all the information elicited by the preceding examinations and in addition thereto a more complete examination into the prior foreign patents is often made than is made by United States Patent Office before grant. It is made from a skeptical standpoint, throwing the burden of proof strongly upon the patent to establish clearly its rights. It may and often does cover both the home and foreign field of prior patents more completely than the Washington Office, and the bearing of any prior patents upon the patent in question is apt to be more fully and carefully considered. Through the interests involved, more time and expense are justified than in the search made by the Washington examiner, and a broader field is usually covered by such an examination.

None of these three searches enumerated does or can cover, however, the entire field embraced in the state of the art, for the reason that at most they can only take account of prior United States and foreign patents and of the more notorious instances of prior publication in well-known technical journals and publications.

But this, although an immense field in itself, is by no means the entire field occupied by the state of the art, for we have in addition thereto to reckon with instances of prior use.

It is, in the nature of things, impossible for either the Patent Office or an attorney making an independent examination to ascertain whether a device patented or proposed to be patented has been already in use, since that use may have taken place in any quarter of the United States, and provided it is such a use as answers the requirements of the patent law, it would nevertheless, in spite of its having taken place in an obscure quarter and for a very short period of time, be sufficient to overturn the patent against which it was brought forward.

Therefore we come to the fourth and last examination into the state of the art, which is practically made in connection with letters-

patent and that is in the course of a suit for its infringement. Every engineer who has acted as an expert assisting counsel in cases of this description is well aware that the defense set up by an infringer is usually divided into two branches; first, non-infringement—that is, that his device as manufactured and sold does not actually in point of mechanical resemblance infringe the plaintiff's patent; and second, that granting that there is infringement in the case, the plaintiff's patent is invalid because anticipated by a prior patent, a prior publication, or an instance of prior use. This latter defense is by far the most common in these cases, and it is this defense which brings up, so far as it is possible to bring it up, the entire state of the art in connection with any patented device involved in such litigation. The interests involved in these suits being frequently very large, both sides are eager, the one to bring forward an instance of anticipation, the other to defend the patent, and the four quarters of the civilized world are usually ransacked for instances of prior publication, prior patent, or prior use.

It is only after a patent has passed this ordeal that it can in any true sense be considered as established, for the reason that it is only in such cases that the state of the art by which the degree of invention shown by a patent is measured is brought forward, if at all, to any complete degree in suits for infringement of letters-patent. All that is then brought forward and passed upon by the court becomes practically *res adjudicata* as to the patent in question. For these reasons it is often said that a patent is not a truly valuable, marketable commodity until it has passed the ordeal of an infringement suit.

We thus see over how enormous a field our inquiry must be extended if we would know the precise status and validity of our patent. It is a field co-extensive with the civilized world and the intelligent activity of men. And the natural conclusion is that patents for invention are precarious and uncertain things unless refined in the fire of an exhaustive judicial investigation.

The foregoing may be considered to present perhaps a very gloomy outlook both for the would-be inventor, the actual patentee, or for those having capital invested in a patent, since it is easy to see that it is quite impossible in the ordinary run of cases to fully ascertain beyond peradventure that the state of the art does not somewhere contain an instance of anticipation. It is only proper, therefore, that we should consider briefly the redeeming features of the situation. In the first place, a very small percentage of the patents granted

are subjected to this ordeal of an infringement suit, and in the case of those involved in an infringement suit there still remains the saving grace accorded by the courts in their point of view regarding such patents.

The grant of a patent by the government creates a *prima facie* presumption in favor of the patent. The courts realize that the patent law has been established for eminently utilitarian purposes, to encourage invention and to promote the industries and the useful arts. Therefore they are active to protect a patent involved in suit and to sustain it until and unless an undoubted instance of prior publication or prior use is brought forward against it.

Every intendment is made in favor of the patent, and an instance of prior publication or prior use must, so to speak, be on all fours with the patent before the courts will allow it as an anticipation. Therefore, as wide as may be the field in which an instance of anticipation may be sought and found, it is nevertheless offset by this fact, that it will not do to find an instance of partial anticipation or to bring forward a part of the patent shown in one prior device and another part in another prior device and; putting them together, say there is here an anticipation of the patent. The court requires that the anticipation shall be a prior publication or prior patent or instance of prior use of a device which substantially in all its details answers to the device involved in suit.

The infringer knows that the burden and expense of proving anticipation lie upon himself, while the patentee can stand upon the grant of his patent by the government until it is overthrown. And before it can be overthrown a clear anticipation must be shown. If there is a doubt, it is resolved by the courts in favor of the patentee. The attacking party cannot piece out a machine by taking one part here, another there, and a third elsewhere, and bring the whole forward as an anticipation of the patent in suit. Most patents to-day are for new combinations of elements all of which, separately considered, are old. Such a patent can only be overthrown by showing the prior use or description of the same elements, or their mechanical equivalents, assembled in a machine performing substantially the same operations. And the more useful or meritorious an invention, the more do the courts incline in its favor when thus attacked, and the stricter the proof they require of clear anticipation.

A question that may naturally be asked I will endeavor to answer here. It may be said, since the United States Patent Office cannot

secure an inventor against this state of the art completely, why does it attempt to do so at all? The foreign patent-granting countries, with the exception of Germany, adopt this view and grant to an applicant whatever he claims as his invention, leaving it to the courts or to future circumstances to determine what the extent of his real invention in the premises may be. This was likewise our method prior to 1836. I think our method of a partial examination is the better one for several reasons, one of the foremost being that it, in a great many instances, saves inventors from a further expenditure of time and money in the promotion of a patent that is clearly invalid by reason of a prior United States patent granted for the same subject-matter. The inventor being met at the outset by a patent on all fours with his idea is saved from going further, and capital is saved from investment in a patent clearly invalid at the outset. Then, too, our office, if it does not show the application to be invalid *in toto,* acts beneficially to restrict the applicant within the field that he may reasonably be entitled to occupy and thus saves him from an erroneous view as to the extent of the ground his patent may cover. Then, lastly, it should be borne in mind that the popular view is that a patent granted by the government amounts to a guarantee of originality, and this impression, however erroneous it may be, as we have seen serves to prevent very many would-be infringers from trespassing upon the territory of a patent, as they would undoubtedly do if the field were known to be open to all, as in the case of patents granted abroad, where there is no examination made as to novelty before grant.

While, therefore, the odds against the validity of a patent seem to be very great, they are in effect and in the practical working out of the system much less than they appear to be, and what has been said upon this subject should not be taken as a discouragement either of inventors or inventions, but simply as a statement showing the true position which a patent occupies in the total field of invention.

DISCUSSION.

The President.—The paper is before the Club for discussion. I think I am safe in saying that the subject-matter is new to most engineers, who probably do not give as much attention to the operation of the patent laws as they should. In these days, with a multiplicity of inventions, especially in the line of mechanical and electrical engineering, it is well to become acquainted with the state of the art as applied to patents.

Carl Hering.—I have been very much interested in this paper, as it states the matter in very clear and concise terms; but I think there are a few points in which Mr. Schermerhorn has given an incorrect impression. He refers repeatedly to the two-year law, and I think gives a wrong impression. If, for instance, I had invented something,—say three years ago,—I would not be debarred from getting a patent for it to-day, even though I had known it, and others around me had known it, for much more than three years. The two-year rule is limited more to the case of contestants. A distinct line should be drawn here. There are really two cases; one is that of contestants for the same invention, and the other that of an applicant making application for a patent and having no anticipation. Mr. Schermerhorn's statements referred to the first case and not to the second, although I think his paper would give the impression that if any one had invented a thing more than two years prior to the date of the application, his patent would not be valid; the latter, I am sure, is not the case, nor is it the impression which he wanted to convey, I believe.

In the beginning of his paper Mr. Schermerhorn says: "The ranks of the experts in patent litigation are necessarily recruited almost wholly from the engineers." While I agree with him that in engineering cases they should be, I don't think it is always the case. He says in another part of his paper that the strength of a patent depends on the degree of advance of the invention. I don't think he meant this, because a patent may be a slight advance in the art and yet be a very strong patent, while another may be a great advance and yet be a very weak patent. I think what he meant was that the strength of the patent depends upon the degree in which it differs from everything that precedes. If it is totally different from everything that precedes, it is likely to be a very strong patent; but if only slightly different, it is probably going to be a very weak patent.

Mr. Schermerhorn.—Yes, Mr. Hering is entirely correct in that respect. It is the degree of difference that is presented by a patent which determines its novelty, not the degree of its improvement; because it turns out, as a matter of fact, that in a great many cases patents are granted for devices which are not nearly of as much use—not nearly as desirable for obtaining the particular end in view—as certain devices already in use. It is not the degree of advance that determines patentability in that sense of the word. The galley proof issued has a good many errors of that kind, I think.

Mr. Hering.—He furthermore says that for the benefit of the inventor and those interested, it is essential to determine whether a patent will be granted by the office. I differ with him on that point. In the first place, I don't think it is essential. In the second place, I don't think it is even necessary, because the search which the patent office makes for $15 is, probably, a much better one than the average patent solicitor can make, because he has not access to the files of the patent office—at least I believe that is the rule now, as this privilege has been withdrawn because it was abused The patent office has files which I think are much more complete than Mr. Schermerhorn has led us to believe. They not only contain the prior American patents, but they contain a great many foreign patents, German and French, and very largely English, and they contain large numbers of references to publications. I have had the privilege of seeing those files, so I can speak from some experience. I therefore do not

think it is essential to determine first whether a patent will be granted by the office or not. The applicant or his solicitor might make a preliminary search to see that there is no broad anticipation, to save the office fee of $15.

The quotations which Mr. Schermerhorn makes from patent decisions are very interesting, and will no doubt be of use to any one working in this field, especially the one concerning the question of anticipation to a combination. It seems to me that the worth or value of the four different kinds of searches that he speaks of here is pretty nearly in proportion to their price. The first search made by the inventor or attorney is the least satisfactory; the second one, made by the patent office, costs $15, and is as good as the government can make. The third, made by a prospective purchaser, is of course in addition to the one made by the office, and is therefore much better and costs much more; the fourth one sometimes costs many thousands or even hundreds of thousands of dollars.

Mr. Schermerhorn said that in making a search one should estimate the earliest date at which it is thought possible that the invention could have been made. I think that would be very difficult to do, for sometimes inventions are made much earlier than we think. Mr. Schermerhorn makes what I consider an error when he says that in making a search to see whether a patent would be valid, that search must be made down to within two years of the time that his applicant made the invention. That surely is not right. Suppose I made an invention yesterday and apply for a patent to-day, and suppose somebody else made that same invention six months ago, or we will say published it; now, if the search does not extend up to to-day, that search will not include the publication of the other inventor, and yet that very publication makes my application invalid. The search should, therefore, in my opinion, extend up to the very date of the invention of the applicant. This is one of the cases in which I think he extended the meaning of the two years' rule too far. He says it is somewhat unusual for the patent office to cite foreign patents. That may be the case in some departments, but I know in the electrical department it is not only not unusual, but is even very frequent; in fact, I know of a great many cases, at least in the electrical department.

I think he is rather unjust to the patent office to say that the search in that office is not a very thorough one. I have often admired the way in which that office finds things that nobody else seems to know anything about. It is remarkable how they will find, among the enormous masses of literature, the very thing that affects your case, and it is always better to have the office find it than to have it found later in the litigation cases.

Mr. Schermerhorn.—Mr. Hering is entirely correct, as far as the two-year rule is concerned. What I meant to say to-night was that if an instance of priority is discovered bearing a date more than two years earlier than the date of application, it is an absolute bar, no matter how far back the applicant can carry his date of invention. It is, of course, a more correct statement of the rule to say that if an instance of priority is found prior to the date of the invention it constitutes a bar. If his date of invention was ten years older than his date of application, and an instance of priority was only five years older than his application, he would be absolutely barred, because by the rule of the office he cannot take full advantage of his ten years. He can only go back two years at most. An instance of anticipation is conclusive if found two years prior to

the date of his application. There is absolutely no remedy for that, but within that two years it is allowed him to show his actual date of invention.

Mr. Hering.—It seems to me that there is another case in which we cannot go back two years. Suppose I file an application and another person had one in the office at the same time; both of us could then show proof of the date of invention more than two years back, and it is then the question which one can give the best proof of the earliest date, even though that date be more than two years. The fact that it was more than two years does not bar us from using that date.

Mr. Schermerhorn.—I have intentionally avoided discussing that qualification of the rule, as it bears upon quite another branch of the patent law than that which we are considering. It is entirely true that, as between rival applicants, the rule does not apply—only between the invention and the state of the art.

The President.—We have with us Professor Richards, of Lehigh University, whom I take the pleasure of introducing, and who will address us on the subject of the paper of the evening.

Prof. Jos. W. Richards.—Mr. President, I am glad to have had the opportunity of hearing Mr. Schermerhorn's paper, but since I did not have the chance to read the paper before coming here, I am hardly prepared to criticize it very intelligently. I have learned much from the paper on points which were previously hazy in my mind, particularly in the line of prior use. There is one point, however, which Mr. Schermerhorn has not explained, and that is why prior use of a process abroad cannot be cited to invalidate a United States patent, as well as prior use at home. I have had it explained to me that, such prior use having to be substantiated by affidavits, the United States cannot admit such foreign evidence because it has not the jurisdiction to punish any falsification of such evidence. I do not know whether this is the real explanation or not, but it sounds plausible.

Regarding the two-year provision, it has always been my custom, in making a search, to search up to the very day of application for the patent, in order to find any possible anticipation.

As to the character of the references cited by the Patent Office, my experience with the metallurgical department has been that the search has been very carefully and accurately made, and I think that I have advised more than one person asking me about the novelty of a metallurgical proposition, that the cheapest way to get a first-class search was to make application for a patent and let the Patent Office make it. It is usually well worth the price of an application. In this department reference is very frequently made to English and other foreign patents and journals, quite as frequently as to prior American patents.

The German office has a way of finding out the relation of a proposed patent to the present state of the art, by posting the application for two or three months before it is allowed, in order that any one in the same line may enter objections to the grant. In this way the office becomes acquainted with the actual state of the art as affecting an application, and many poor patents are thus quenched, while a really novel one endures the ordeal.

Mr. Hering.—I would like to ask Professor Richards whether this three months' publication of the application, in Germany, bars any one else from

afterward showing that he had used the same process or invention earlier. In other words, does the government virtually say to others that they have to give notice within those three months or else they have no claims later to show that they have used this invention prior to that application?

Professor Richards.—I believe that the German Patent Office does not exclude others afterward from coming into court and proving a patent invalid. The practice of posting the application does not bar any person from contesting the patent after it is granted. The practice simply works to advise the Patent Office clerks, who are usually rather clerks and bookworms than practical men, how, in the present state of the art, the industry views an application; this brings them more into touch with practical men, and prevents the issue of very weak patents.

Mr. Schermerhorn.—There is one point which Professor Richards has mentioned in connection with prior use that is of particular interest. The reason why instances of prior use are confined to this country is perhaps this: It has been considered unjust that an instance of prior use, it may be many years ago, of the present invention (in Chile, South America, Brazil, or some far-off corner of the globe, or one of the British colonies) should be allowed to prevent the issue of a patent by our government for a device which may be of a high degree of usefulness at the present day. Prior foreign use and prior foreign publication therefore stand on entirely different footings. The latter bars a patent in this country; the former does not. There is, however, another way in which a prior foreign use may overturn a United States application or patent, and that is this: The inventor here is obliged to make affidavit that he believes himself to be the original and sole inventor of this device. Now, if it should be proved that this inventor knew of this prior use and notwithstanding applied for a patent upon the device in the United States, his application or his patent could very possibly be overthrown by showing that he made a false affidavit.

P. J. A. Maignen.—I wish to ask Mr. Schermerhorn if French patents more than two years old would prevent the same invention being patented in this country now, considering that in France the patents until lately have not been printed for public distribution; whether the fact that the patent is recorded in the French Patent Office amounts to publication according to American law; also, whether an invention used in France more than two years ago, but not patented there, could now be protected in this country by the original inventor.

Mr. Schermerhorn.—As to publications of the French Patent Office, of course if those patents are published and spread broadcast, if they enroll the original application when it is granted and made the basis of a patent, if that is enrolled in such a way as to be accessible to the public, it would constitute a publication. It is not necessary that the patents issued by the government should be issued in pamphlet form, as in the United States and Great Britain; but if only one copy were retained by the office, and that copy could be examined by the public at large, it constitutes a publication. As to a use in France, I think that would come within the rule stated if it was not in use in the United States. If, of course, that use is transplanted to this country, it becomes prior use. If it is made the basis of a description in the newspapers, setting forth

the entire device, to enable any one to construct it and use it, it would constitute prior publication in France, and therefore anticipation.

Eugene M. Nichols.—I would like to ask Mr. Schermerhorn if he could give us the precise wording of the rule of the Patent Office in regard to this two-year business. I think that will explain more than any discussion.

Mr. Schermerhorn.—(Quoting.) "A patent may be obtained by any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, *or more than two years prior to his application,* and not in public use or on sale in the United States for more than two years prior to his application, unless the same is proved to have been abandoned, upon payment of the fees required by law and other due proceedings had."

James Christie.—What date does that originate?

Mr. Schermerhorn.—The date is not given here.

Mr. Nichols.—What is the date of the pamphlet?

Mr. Christie.—The act is comparatively recent.

Mr. Schermerhorn.—The act is in '97 or '98.

Mr. Nichols.—Well, that particularly states that if the invention is over two years old it bars them. That is as plain as you can make it. If it is an article of commerce two years prior, that is old. That is the way it is worded.

A Member.—That is an amendatory clause from Congress to the Patent Office that they shall do so if the conditions are complied with; but whether they shall do otherwise if the conditions interfere is really left to the Patent Office.

A Member.—There is one point in connection with the state of the art: A law has recently been passed in England, by Parliament, and also approved by the King, in which searches on applications have been authorized, and although this has not gone into effect, it is to go into effect upon the action of the Board of Trade; and they are very closely following there the law in this country, and it seems that our inventors are going over there and our methods are being followed. In regard to the mention made by Mr. Hering,—access to the files of the Patent Office,—the files of the Patent Office are open to everybody, with the exception of pending applications, forfeited applications, and abandoned applications. Those are not to be seen unless by order of court, which has to be obtained, and in case of a suit; in that case they may be seen and copies had of them to prove certain questions.

L. Y. Schermerhorn.—Could hieroglyphics be cited as publications? (Laughter.)

ABSTRACT OF MINUTES OF THE CLUB.

Regular Meeting, January 3, 1903.—Vice-President Smith in the chair. Fifty-two members and ten visitors present.

Mr. Charles Piez read a paper upon "The Handling and Storing of Iron Ore." The subject was discussed by Messrs. James Christie, Edwin F. Smith, J. Chester Wilson, A. C. Johnson, and others.

Mr. Richard G. Develin exhibited and described for Mr. Joseph T. Richards a couple of lantern slides, showing the changes which have been made in the bridges, tracks, and stations on the line of the Pennsylvania Railroad, between the east side of the Schuylkill River and Fifty-second Street, West Philadelphia.

Annual Meeting, January 17, 1903.—President Hartley in the chair. Sixty-three members and ten visitors present.

An amendment to the By-Laws was offered, proposing to amend Article V, Section 11, so as to provide for a nominating committee to select candidates for the annual election of officers.

The annual report of the Board of Directors and that of the Treasurer were presented and, upon motion, were accepted and ordered to be filed.

The Treasurer reported the names of six active and two associate members dropped from the rolls for arrears in dues to the Club.

Mr. Henry J. Hartley, retiring President, presented the annual address, giving a résumé of some of the most notable engineering achievements during the twenty-five years since the organization of the Club.

The Tellers reported the election of the following officers for 1903: President, Edwin F. Smith; Vice-President, Horatio A. Foster; Secretary, J. O. Clarke; Treasurer, Geo. T. Gwilliam; Directors, James B. Bonner, D. A. Hegarty, and Geo. Neville Leiper.

The new President, Mr. Edwin F. Smith, thanked the Club for the honor conferred upon him and congratulated the members upon the present healthy condition of the Club.

Conversational Meeting, January 31, 1903.—Vice-President Comfort in the chair. One hundred and twenty-five members and visitors present.

Mr. Henry Wiederhold (visitor) read a paper on "Asphalt and Asphalt Mastic." The subject was discussed by Director Haddock, Messrs. Geo. S. Webster, Wm. H. Brooks, Clifford Richardson, Martin L. Gardner, John C. Trautwine, Jr., Edwin Clark, James G. Davis, Charles M. Burns, Emile G. Perrot, and Eugene M. Nichols.

Business Meeting, February 7, 1903.—The President in the chair. Fifty-nine members and visitors present.

The election of Mr. W. B. Riegner to the Board of Directors for the unexpired term of Mr. Charles Hewitt, resigned, was announced.

Mr. Joseph L. Ferrell (visitor) presented a paper upon "Apparatus for and Methods of Treating Wood to Protect it from Fire and Preserve it from Decay." A prolonged discussion brought out the cheapness and rapidity of applying preservatives by the new method.

Upon motion a special vote of thanks was tendered the Information Committee and Mr. Gwilliam for arranging the trip to New York, and to Mr. Wiederhold, Mr. Parsons, Mr. Briggs, and other gentlemen for their courtesy to the Club on the trip.

The Tellers reported the election of Messrs. Walter F. Ballinger, Howard W. DuBois, Julian O. Ellinger, J. Lawrence Hagy, E. P. Haines, John M. Hartman, Emile G. Perrot, A. G. Warren, and David Thomas Williams to active membership, Messrs. Holstein deHaven Bright and Carl Rossmassler to junior membership, and Walter B. White to associate membership.

Business Meeting, February 21, 1903.—The President in the chair. One hundred and thirty-five members and visitors present.

The Secretary announced that members were cordially invited to attend the meetings of the local chapter of the American Institute of Electrical Engineers, held in the Club House on the second Monday of each month.

Mr. John W. Hill (visitor) presented tne subject of the "Improvement, Extension, and Filtration of the Water-supply of Philadelphia."

Mr. James Christie explained the considerations which led to the introduction of the amendment proposed at the annual meeting, stating that nominations made by the committee would not prevent other nominations at the pleasure of the members of the Club.

Business Meeting, March 7, 1903.—The President in the chair. Sixty-four members and visitors present.

An amendment to article IV, Sections 4, 5, and 6, of the By-Laws, was submitted, in order to make the Secretary and the Treasurer members of the Board of Directors, and in order to have their salaries fixed before their election.

Mr. H. B. Schermerhorn (visitor) read a paper upon "The 'State of the Art' in Patent Cases."

The President, as a result of the vote, announced that the amendment to Article V, Section 11, of the By-Laws, in order to effect a change in the method of nominating officers of the Club, was adopted.

The Tellers reported the election of Messrs. J. T. Campbell, E. Collins, Jr., J. Harvey Gillingham, T. Chalkley Hatton, William H. Lindsey, W. L. Plack, Henry Hodge Quimby, and H. F. Sanville to active membership, A. P. Hume to junior membership, and John Nazel and C. P. Weaver to associate membership.

Regular Meeting, March 21, 1903.—The President in the chair. Eighty-eight members and visitors present.

Mr. Howard W. DuBois presented a paper on "Reconnaissance Methods of Surveying in a Mountainous District."

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Special Meeting, January 7, 1903.—Present: Vice-Presidents Smith and Comfort, Directors Foster, Riegner, McBride, and Myers, the Secretary, and the Treasurer.

The Executive Committee recommended that the annual report of the Board should be in the same form as that of last year, and presented the reports of the several committees. These were considered, slightly modified, and arranged in proper form for publication.

Mr. Charles Hewitt presented a letter requesting the Board to accept his resignation. This was upon motion laid on the table.

The Treasurer's report showed:

Balance, November 30, 1902,	$1095.94
December receipts,	1000.97
	$2096.91
December disbursements,	755.05
Balance, December 31, 1902,	$1341.86

Regular Meeting, January 17, 1903.—Present: President Hartley, Vice-Presidents Smith and Comfort, Directors Foster, Levis, Riegner, and McBride, the Secretary, and the Treasurer.

The House Committee was authorized to purchase a table for the meeting-room, suitable for the use of the Presiding Officer and the Secretary.

Organization Meeting, January 23, 1903.—Present: The President, the Vice-Presidents, all Directors, the Secretary, and the Treasurer.

In view of Mr. Hewitt's pressure of business, his resignation was, upon motion, accepted with much regret, and Mr. W. B. Riegner was elected to fill the unexpired term of Mr. Hewitt.

The President announced the following committees: Finance, Messrs. Horatio A. Foster, H. K. Myers, W. B. Riegner; Membership, Messrs. W. B. Riegner, James B. Bonner, Horatio A. Foster; Publication, Messrs. Silas G. Comfort, James B. Bonner, D. A. Hegarty; Library, Messrs. Geo. Neville Leiper, Silas G. Comfort, H. K. Myers; Information, Messrs. Thos. C. McBride, D. A. Hegarty, Geo. Neville Leiper; House, Messrs. H. K. Myers, D. A. Hegarty, Thos. C. McBride.

Upon motion a special committee, consisting of the Treasurer (as Chairman), the Secretary, and the Chairman of the Publication Committee, was authorized

to make contracts for advertisements in both the PROCEEDINGS and the Directory.

The Information Committee was authorized to call a conversational meeting of the Club for January 31st, and the House Committee to provide luncheon for that evening.

The Secretary was directed to communicate with the various engineering clubs of the country to inquire if they would exchange the privileges of their club houses with The Engineers' Club upon presentation of membership cards.

ADJOURNED MEETING, February 6, 1903.—Present: The President, Vice-Presidents Comfort and Foster, Directors Hegarty, Leiper, McBride, and Myers the Treasurer, and the Secretary.

The Tellers of Election were appointed as follows: Washington Devereux, John T. Loomis, William E. Bradley, I. Wendell Hubbard, Francis Head, and H. P. Cochrane.

Auditors for 1903: Messrs. Dallett, Humphrey, and Spangler.

Committee on the Relations of the Engineering Profession to the Public: John Birkinbine, Chairman; L. Y. Schermerhorn, John C. Trautwine, Jr., Carl Hering, James Christie, Edgar Marburg, James M. Dodge.

The appointment of the Committee on New Club House was postponed.

The salary of the Clerk, Frederick W. Myers, was increased from $70 to $75 per month, dating from February 1, 1903.

REGULAR MEETING, February 21, 1903.—Present: The President, Vice-President Comfort, Directors Riegner, McBride, Hegarty, and Leiper, the Treasurer, and the Secretary.

The Treasurer's report showed:

Balance, December 31, 1902,	$1341.86
January receipts,	1600.00
	$2941.86
January disbursements,	440.38
Balance, January 31, 1903,	$2501.48

The following appropriations were made for the fiscal year 1903, two-thirds of the appropriation of the Publication Committee to be available before August 1st, and one-half of each of the others to be available before the same date:

House Committee,	$2400.00
Publication Committee,	1000.00
Library,	150.00
Information,	150.00
Office expenses,	500.00
Salaries,	1735 00
	$5935.00

REGULAR MEETING, March 21, 1903.—Present: The President, Vice-President Comfort, Directors Riegner, McBride, Myers, Leiper, and the Secretary.

The Treasurer's report showed:

Balance, January 31, 1903,	$2501.48
February receipts,	418.02
	$2919.50
February disbursements,	317.15
Balance, February 28, 1903,	$2602.35

The Library Committee was directed to have a portion of a list of periodicals submitted bound, including those for general reference.

The House Committee reported that shelves had been secured for the reference library in the Board Room.

The matter of appointing the New Club House Committee was laid on the table.

ADDITIONS TO GENERAL LIBRARY.

FROM WM. H. ROBINSON, PHILADELPHIA.

Experimental Researches in Steam Engineering, vols. I and II, 1863–1865. B. F. Isherwood.

FROM WM. B. PHILLIPS, DIRECTOR, UNIVERSITY OF TEXAS MINERAL SURVEY, Austin, Texas.

Bulletin No. 5, Minerals and Mineral Localities of Texas, December, 1902.

FROM BOSTON TRANSIT COMMISSION, BOSTON, MASS.

Eighth Annual Report, June, 1902.

FROM COMMISSIONER OF EDUCATION, WASHINGTON, D. C.

Annual Report, vols. I and II, 1900–1901.

FROM AMERICAN SOCIETY FOR TESTING MATERIALS, PHILADELPHIA.

Proceedings of Fifth Annual Meeting, vol. II, 1902.

FROM THE CITY PARKS ASSOCIATION OF PHILADELPHIA.

Fifteenth Annual Report, 1903.

FROM THE LIBRARY COMPANY OF PHILADELPHIA.

Bulletin, March, 1903.

FROM FAIRMOUNT PARK ART ASSOCIATION.

Thirty-first Annual Report, 1903.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XX. JULY, 1903. No. 3

IMPROVEMENT, EXTENSION, AND FILTRATION OF THE WATER-SUPPLY OF PHILADELPHIA.

JOHN W. HILL.

Read February 21, 1903.

Mr. President and Gentlemen:

I have been introduced as offering a paper this evening; I regret to say that what I will give you is not in the form of a paper. The time was not available to prepare a paper such as I should like to read. So in the absence of written matter I will put on the screen a number of views of the work now in progress, and while these are being shown will endeavor to entertain you with a desultory talk about the details of the work embraced in the general improvement of the water-supply. After the views have been presented I wish to call your attention to some features of the work which cannot be represented by or do not require the aid of the lantern.

The improvement, extension, and filtration of the water-supply of Philadelphia involves four separate propositions:

1. The readjustment of sources of supply to limit the maximum consumption of water from the Schuylkill River to 150,000,000 gallons per day of twenty-four hours.

2. The readjustment of the water-distribution districts so that the present Fairmount, Corinthian, East Park, Queen Lane (in part),

and Wentz Farm, or Frankford, districts will hereafter receive their water-supply from the Delaware River, all of which, excepting the Wentz Farm district, are now supplied from the Schuylkill River.

3. The filtration of the entire water-supply from the Schuylkill and Delaware Rivers.

After these things are accomplished there will then arise the fourth proposition—viz., to meter all water services, or readjust the water rates to meet the added cost of filtering the supply.

In the reports of the experts—and wisely, it is thought—it was deemed advisable to limit the consumption of water from the Schuylkill River to 150,000,000 gallons per day, which volume of water represents about the minimum dry-weather stream-flow.

The ultimate available working capacity of the Belmont filters, as planned, will be 97,000,000 gallons per day.

The ultimate capacity of the Roxborough works will be, for:

Lower Roxborough (five filters), ...	12,000,000	gallons per day.
Upper Roxborough (seventeen filters),..	45,500,000	" "
Roxborough Service, ...	57,500,000	" "
Belmont (twenty-six filters),..........	97,000,000	" "
Total from Schuylkill River,......	154,500,000	" "

The actual capacity of the works now under contract will be, for:

Belmont (eighteen filters),............	67,000,000	gallons per day.
Lower Roxborough, ...	12,000,000	" "
Upper Roxborough (eight filters),.....	20,000,000	" "
	99,000,000	" "

or about two-thirds of the available capacity of the land taken by the city for filtration of the Schuylkill water.

The ultimate works at Belmont will embrace twenty-six filters of 0.73 acre area.

The ultimate works at Upper Roxborough may embrace seventeen 0.70-acre filters, while the works at Lower Roxborough cannot conveniently be enlarged, but will probably always remain as constructed —viz., five one-half-acre filters.

The Belmont and Lower Roxborough filters will be worked in connection with preliminary or roughing filters, while the Upper Roxborough filters, at least in their early history, will be worked only with subsided water from the Upper Roxborough reservoirs.

Experience may demonstrate the wisdom of adding a system of

preliminary filters to the Upper Roxborough works, which can be done with some unimportant changes in the works as constructed, and instead of seventeen filters, the extension would probably be limited to twelve filters, or four more than the present number, working at the rate of 4,200,000 gallons per filter per day, or a total available capacity, allowing 20 per cent. for reserve, of 40,300,000 gallons, making the ultimate draft on the Schuylkill River 149,300,000 gallons per day, or nearly 150,000,000 gallons as recommended by the experts.

The wisdom of limiting the supply of Schuylkill water to the Roxborough and Belmont districts will be seen when the growth of population west of the river in the present wards, the Twenty-fourth, Twenty-seventh, Thirty-fourth, and Fortieth, is considered. The present population of West Philadelphia is estimated at 170,000, and the population fifty years hence, it is believed, will reach 450,000, which, at the present rate of consumption, will require over 90,000,000 gallons per day; or if restrictions of waste are adopted, the consumption will certainly reach 65,000,000 to 70,000,000 gallons per day. Combining the estimated minimum consumption of West Philadelphia with the estimated capacity of the Roxborough filters, there will be consumed from the Schuylkill River from 120,000,000 to 145,000,000 gallons of water per day of 24 hours.

A part of the water filtered at Roxborough will be supplied to the higher levels of the present Queen Lane district; the remainder of this district, together with the other districts mentioned, will hereafter be supplied with filtered water from the Torresdale works on the Delaware River.

With a view to presenting the more important works entering into the improvement of the water-supply, I have had lantern slides prepared from the plans and photographic views of the works, and will briefly describe these as the views are put on the screen.

Diagram of Population and Water Consumption.

The diagram (Fig. 1) shows the curves of population and water consumption from 1860 to 1900, and is offered to illustrate what many of the audience may already know—viz., that the very large per capita consumption of water has occurred entirely during the last seventeen years of the period of time embraced. Since 1885 the consumption has risen from 72 gallons per capita to 222 gallons per capita. You will observe that the increase in per capita consump-

tion from 1860 to 1885 was 36 gallons, while from the latter year to 1900, the increase was 150 gallons. This is partly to be accounted for by the large increase during the past twenty years of the manufacturing industries in Philadelphia, partly by the almost universal use, even in the most modest dwellings and business houses, of modern sanitary appliances, and partly by increased application of water to the arts. Philadelphia is said to be a city of homes, and this

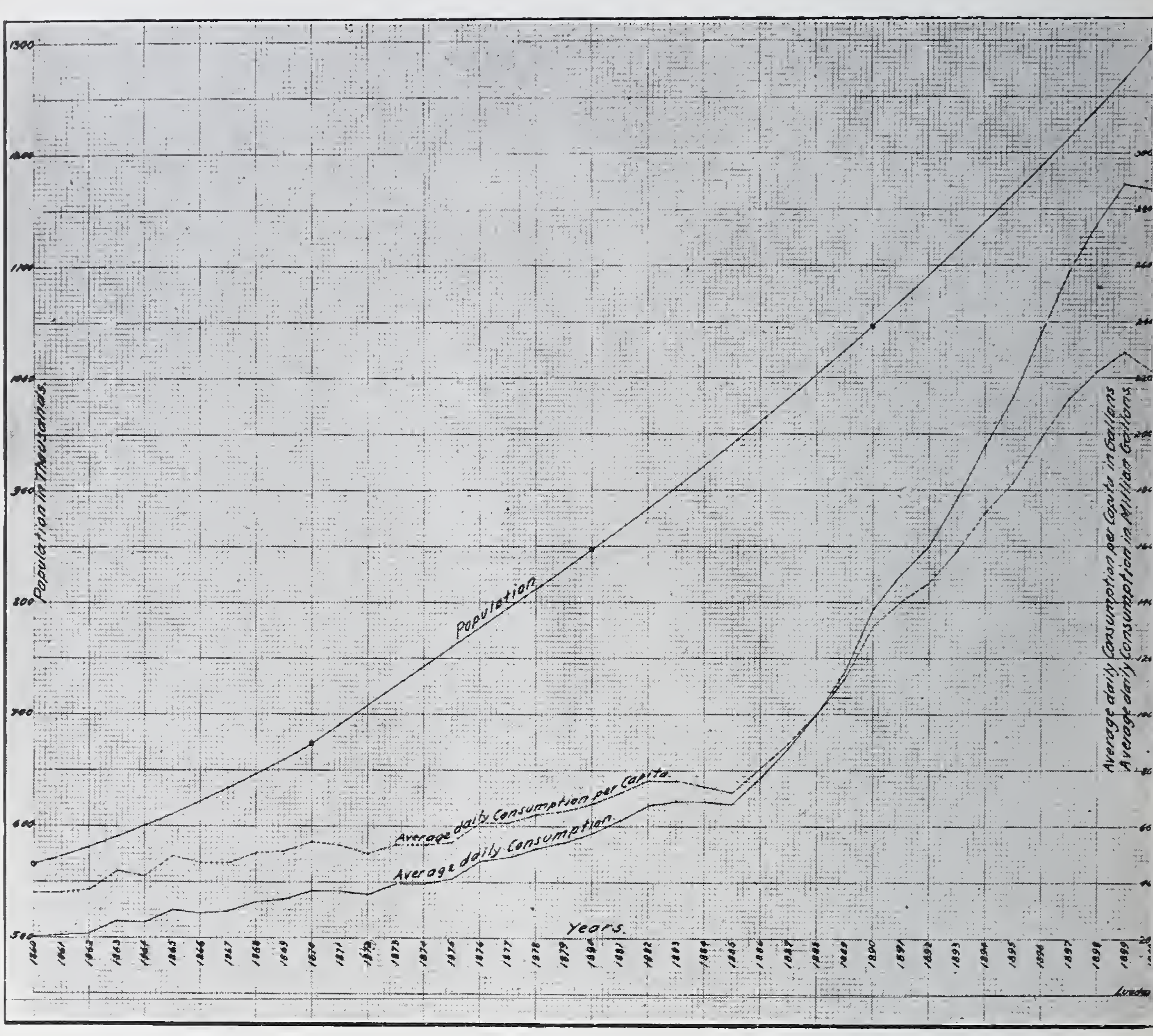

Fig. 1.—Population and Consumption of Water in Philadelphia, 1860–1900.

statement is true as compared with other large cities of the United States. Here, with a few exceptions in the older wards of Southwark, and the territory lying next to the Delaware River, the renter of limited means, instead of seeking a domicile in a barracks or tenement-house, as is the custom in New York, Cincinnati, St. Louis, Chicago, and other large cities, can obtain a separate dwelling at

a cost of a few dollars per month, in which he is isolated from his neighbors, and is master of his home from the cellar to the roof and from the front to the rear of the premises. In his home, however unpretentious it may be, he will find gas, water, bath-tub, and water-closet, which are well adapted to the necessities of his family. It will thus be found that, whereas in this city a family of four or five persons will have from two to three water spigots in the house, in other large cities as many as fifty persons living on one floor of a tenement-house may have to draw water for all purposes from a single spigot; and in some so-called barracks in Cincinnati, containing three or four stories or floors, the public water is not found above the ground floor, and all tenants are compelled to carry water to their respective abodes from a single hydrant in the rear yard. Under these conditions of water-supply it can be well understood that the per capita consumption in this city is bound to be greater than in some other large cities, and the people as a whole will be cleaner in person and enjoy greater home comforts so far as these may be due to the public water-supply.

It is sometimes thought that the large per capita consumption in Philadelphia is due partly to leakage of joints in the street mains, but such information as has come to me on this point does not point to this loss as a large or even material factor. I remember a statement made a few years ago by a well-known Boston engineer, that in a system of water mains in a New England city laid under his supervision the leakage amounted to 25 per cent. of the gross consumption; but water mains are not laid in that way here.

Map of City, Showing Sketch Plan of Work.

The sketch map (Fig. 2) shows that portion of the city which lies north of Market Street and includes all the new works embraced in the improvement of the water-supply.

Beginning with the Belmont, or West Philadelphia, works, which will supply with filtered water all the city territory west of the Schuylkill River, the filtering works are located on Belmont Avenue between City Avenue and Lankenau Avenue, and occupies the tract of land bounded by Belmont Avenue, City Avenue, Monument Avenue, Lankenau Avenue, and Overbrook Avenue, in all about 57 acres, nearly all of which is occupied by the works now under construction or by the plans for future extension of the filters.

The Belmont works as they are being constructed will contain a

sedimentation reservoir consisting of two divisions, with a capacity at the flow line, 279 feet above C. D. (city datum), of 72,000,000

Fig. 2.—Location of Works.

gallons; a system of preliminary filters of a daily capacity (at present) of 40,000,000 gallons, to be extended to 97,000,000 gallons to meet

future consumption; eighteen plain sand filters, each of approximately 0.73 acre net sand area, and a clear-water basin of 16,500,000 gallons capacity at the flow line, 239 feet above C. D.

The raw water for the Belmont works will be pumped from the present Belmont pumping station to the sedimentation basins at the intersection of Belmont Avenue and City Avenue, two new lines of 36-inch rising main having been recently laid through West Park and Belmont Avenue for that purpose.

The Roxborough works consist of two sets of filters, one on Dearnley Avenue west of the Lower Roxborough reservoir, and the other on Port Royal Avenue and Hagy Mill Road. The Lower Roxborough works consist of five one-half-acre filters, and a clear-water basin of 3,000,000 gallons capacity, to which will shortly be added a system of preliminary filters of 12,000,000 gallons daily capacity, which will be the ultimate working capacity of the Lower Roxborough station.

The Upper Roxborough works consist of eight filters, each of about 0.70 acre net sand area, and a clear-water basin of 8,000,000 gallons capacity. No preliminary filters are at present contemplated for the Upper Roxborough station.

The Lower Roxborough filters are placed at an elevation from which 60,000 to 80,000 population can readily be supplied by gravity. The elevations of the works at this station are as follows:

Lower Roxborough subsiding reservoir,	366.00	C. D.
Level of water in preliminary filters,	350.00	"
Level of water, filter No. 5,	343.00	"
Level of water, filter No. 4,	340.25	"
Level of water, filter No. 3,	337.50	"
Level of water, filter No. 2,	334.75	"
Level of water, filter No. 1,	332.00	"
Level of water, clear-water basin,	325.75	"

The filters at Lower Roxborough, by reason of the topography, are arranged in terraces, each filter rising 2 feet 9 inches above the next below. By the adoption of Lower Roxborough reservoir as a subsiding basin the pumpage of 12,000,000 gallons per day through an added head of 48 feet is avoided. In the plans of the experts this reservoir was to be abandoned entirely, and all pumpage from the Shawmont station was to be to the Upper Roxborough reservoirs at elevation 414 feet C. D., but careful study of the general problem indicated the advantage of utilizing the Lower Roxborough reservoir

as a subsiding basin for a system of filters designed to supply all of the Twenty-first Ward lying below elevations 250 C. D., and parts of the Twenty-second and Thirty-eighth Wards. At the present time these works are supplying from 6,000,000 to 7,000,000 gallons of filtered water per day, of the following quality, as shown by the weekly report of the Testing Station for the week ending February 14th:

Bacteria per cubic centimeter, clear-water basin, ...	52.0
Turbidity, parts per million, silica standard, ...	5.0

The average of the effluents flowing from the five filters to the clear-water basin was as follows:

Bacteria, per cubic centimeter, ...	77.0
Turbidity, silica standard, ...	4.4

showing a marked reduction in the bacterial content of the filter effluents while passing through the clear-water basin. The reason for this is supposed to be the lack of food material for the support of bacterial life in the filtered water.

The presence or absence of fish in water has been mentioned as a test of quality. Certain species of fish, like the carp, for instance, are often found to flourish in waters polluted by organic wastes, while other kinds, like the mountain trout, more fastidious in their tastes, are never found in any but the clearest and naturally purest upland waters. In all cases, however, there must be enough organic matter in any water to support even fish life, and an estimate of the quality of a water-supply for domestic purposes, from the presence or absence of any particular fish, can only be relative. A water wholly destitute of organic matter could not support fish life, while in a water heavily polluted with sewage certain kinds of fish would die, possibly for lack of oxygen.

It has been stated that, since the introduction of the filtered water into Manayunk, goldfish cannot live in it, which is an indication that some, if not quite all, of the sewage wastes have been removed by plain sand filtration from the Schuylkill water.

The accepted standard of water purification by the filters of Europe is 100 bacteria per cubic centimeter of effluent. No turbidity standard for potable water, so far as I am aware, has ever been set either here or abroad, but the nearest approach to this has come from the Medical Society of the District of Columbia, which, as I am informed by

Colonel Miller, in charge of the Washington aqueduct, has expressed the opinion that a filtered water showing by the platinum wire standard a turbidity of 0.025, corresponding to about 6.25 parts per million by the silica standard, would meet all reasonable requirements.

The Upper Roxborough filters will supply parts of the Twenty-first and Twenty-second Wards by gravity, and through the Roxborough auxiliary pumping station will furnish filtered water to Mt. Airy, Chestnut Hill, and all the higher elevations in the Roxborough district. The elevations of the works at this station are as follows:

Upper Roxborough reservoirs, ...	414.00 C. D.
All filters at uniform elevation, ...	419.00 "
Clear-water basin, ...	410.00 "

The filters at Upper Roxborough are completed, lacking the filtering materials, which are now being placed, and within a few months this station will be put in service with an early capacity of 15,000,000 gallons per day, which will gradually be increased to over 20,000,000 gallons, as the new purveying districts have been adjusted to a proper consumption of the combined capacity of the Upper and Lower Roxborough stations.

The complete service at Lower Roxborough will be the pumpage of raw water from the Schuylkill River at Shawmont to the Lower Roxborough subsiding reservoir, from which it will be drawn continuously by gravity to the preliminary filters, thence to the final filters, thence to the clear-water basin, and thence to the distribution districts, through a double line of 30-inch cast-iron pipes; one, line "B," leading to the Manayunk district, Twenty-first Ward, and one, line "A," leading to the Germantown district, Twenty-second Ward.

The complete service at Upper Roxborough will be the pumpage of the raw Schuylkill River water to the Upper Roxborough subsiding basins, thence by gravity to the low-service pumping station on Eva Street near Shawmont Avenue, from which the subsided water will be lifted by centrifugal pumping machinery to the filters; thence to the clear-water basin at Port Royal Avenue and Hagy Mill Road, and thence through a single line of 48-inch cast-iron pipe by gravity to the Roxborough auxiliary (high-service) pumping station, where the supply for Chestnut Hill and Mt. Airy will be taken off and the remainder flow by gravity to levels in the Twenty-

first and Twenty-second Wards, which are too high to be supplied from the Lower Roxborough filters. The clear-water basin of the filters at Upper Roxborough is at an elevation 84.25 feet higher than the clear-water basin at Lower Roxborough.

The Upper Roxborough filters have a flow line 5 feet higher than the flow line of the subsiding reservoirs, and hence the necessity for the second low-service pumping lift just mentioned. In the subsiding basins at both Upper and Lower Roxborough the process of sedimentation will be continuous; that is, the water-level will be maintained at an approximately constant elevation, and the rate of pumpage to the basins will also be the rate of filtration at the two stations.

The capacity of the Lower Roxborough subsiding basin at flow line is about 13,000,000 gallons, or slightly more than one day's work of the filters when the preliminary filters have been completed. The capacity of the Upper Roxborough subsiding reservoirs is 147,-000,000 gallons, or about seven times the easy capacity of the filters. In the early history of this station it could not be worked above 15,000,000 gallons per day because of the limited distribution district to be supplied previous to the completion of the Torresdale filters and readjustment of the supply to the present Queen Lane district.

The Torresdale filters, located on the west bank of the Delaware River, north of Pennypack Creek, are intended to supply a present population of 1,100,000, comprising the present Fairmount, East Park, Queen Lane (in part), and Wentz Farm districts. The filter capacity intended by the experts to be located at the Queen Lane reservoirs has in the plans been combined with the Torresdale works.

At the present time the work of construction at Torresdale embraces fifty-five three-quarter-acre filters, and a clear-water basin of 50,000,000 gallons capacity. The plans contemplate an addition of ten filters, each of three-quarter-acre net sand area, to provide for the supply of filtered water to the Queen Lane district.

The total capacity of the Torresdale works, based on sixty-five filters, with preliminary filtration of the water, will be 248,000,000 gallons per day of twenty-four hours.

From the clear-water basin at Torresdale the filtered water will flow by gravity to shaft No. 1, of the Torresdale conduit, thence through the conduit to shaft No. 11 at Lardner's Point, where it will rise and be distributed to the old and new pumping stations. (See Fig. 19.) These stations will have a combined daily pumping capacity,

when completed, of 290,000,000 gallons, of which 240,000,000 gallons will be assembled in the two new engine houses.

From the Lardner's Point pumping station the filtered water will be pumped into the Lardner's Point pipe distribution system, and conveyed to Frankford Avenue and Frankford Creek, whence the water will flow partly southward through mains on Frankford Avenue and partly westward and southwardly through mains to be laid from the intersection of Torresdale and Kensington Avenues.

The Lardner's Point pipe distribution system consists of four lines of 60-inch cast-iron pipe in Robbins Street, from Delaware Avenue to Tacony Street, and three lines of the same size and kind of pipe in Tacony Street, from Robbins Street to its junction with Torresdale Avenue; thence as three lines of pipe, the same as before, in Torresdale Avenue to Kensington Avenue. The three lines of pipe cross Frankford Creek between Frankford and Kensington Avenues. The fourth line of 60-inch pipe will in the future be laid in Robbins Street from Tacony Street to Torresdale Avenue and in Torresdale Avenue from Robbins Street to Kensington Avenue, provision being made in all the valve chambers west of Tacony Street for ultimate connection with the fourth line of pipe when laid.

From valve chambers Nos. 5, 6, and 7, at Torresdale Avenue and Frankford Avenue, three lines of 48-inch pipe will be laid southward on Frankford Avenue, and from valve chambers Nos. 8, 9, and 10, at Torresdale and Kensington Avenues, four lines of 48-inch pipe will be laid westwardly on Torresdale Avenue, and two lines of 48-inch pipe southwardly on Kensington Avenue, to lead into and connect with the principal mains in the present Queen Lane and East Park distribution districts.

The Oak Lane reservoir of 70,000,000 gallons capacity, at elevation 210.00 C. D., forms part of the Torresdale works and is intended as a compensating reservoir for filtered water, and to fix the head against which the Lardner's Point pumps will in the future work. This basin is now under construction, on the site lying between Third and Fifth Streets and Medary Avenue and Sixty-fifth Avenue North, adjacent to the suburb of Oak Lane.

The 48-inch rising main which will connect this with the Queen Lane and East Park distribution systems will be laid in Fifth Street from Erie Avenue to Chelten Avenue, where it will connect with the reservoir gate chamber.

The total land appropriated for the filters and other works comprises 462.502 acres, divided as follows:

Upper Roxborough station,	34.518	acres.
Belmont station,	60.572	"
Torresdale station,	343.500	"
Oak Lane reservoir,	20.823	"
Lardner's Point pumping station,	3.089	"

The Belmont Works.

Figure 3 shows the general plan of the Belmont works, which embraces the two settling basins, preliminary filters, plain sand filters, and clear-water basin, as the principal features, and as auxiliaries an administration building, containing offices for the management of the works, boiler-room, engine-room, and laboratory for the analytical examination of the water samples, pumping machinery to supply water to the sand washers and ejectors, and to pump water drained from filters taken out of service into filters which are in service, together with electrical generators to supply light to the filters, gate and regulator houses, and administration building.

Referring to figure 3, showing the Belmont subsiding basins, it will be noticed that the raw water from the Schuylkill River will flow through a 48-inch pipe lying on the bottom of the reservoir to the northeast corner, where it will issue through the open branches of "tees" in the pipe, and not through the end, which will be plugged.

The water rises from the bottom to the top of the easterly compartment of the basin and is drawn from the surface by a floating pipe connected with another 48-inch pipe on the floor of the westerly compartment of the basin, from which it is discharged at the northwest corner of the basin through the open tees near the end of the pipe; the end of the pipe being plugged as it is in the easterly compartment of the basin. The water then rises from the bottom to the top of the westerly compartment and is drawn from the surface by a floating pipe through the gate chamber to the preliminary filters south of Ford Road. It will thus be seen that during the period of continuous subsidence in the reservoirs the raw water passes from end to end, and from the bottom to the top, of each division of the reservoir before it is drawn off to the filters.

Figure 4 shows the operations in the west division of the Belmont sedimentation basins, which indicates the character of material which the contractors were required to remove; much of the excava-

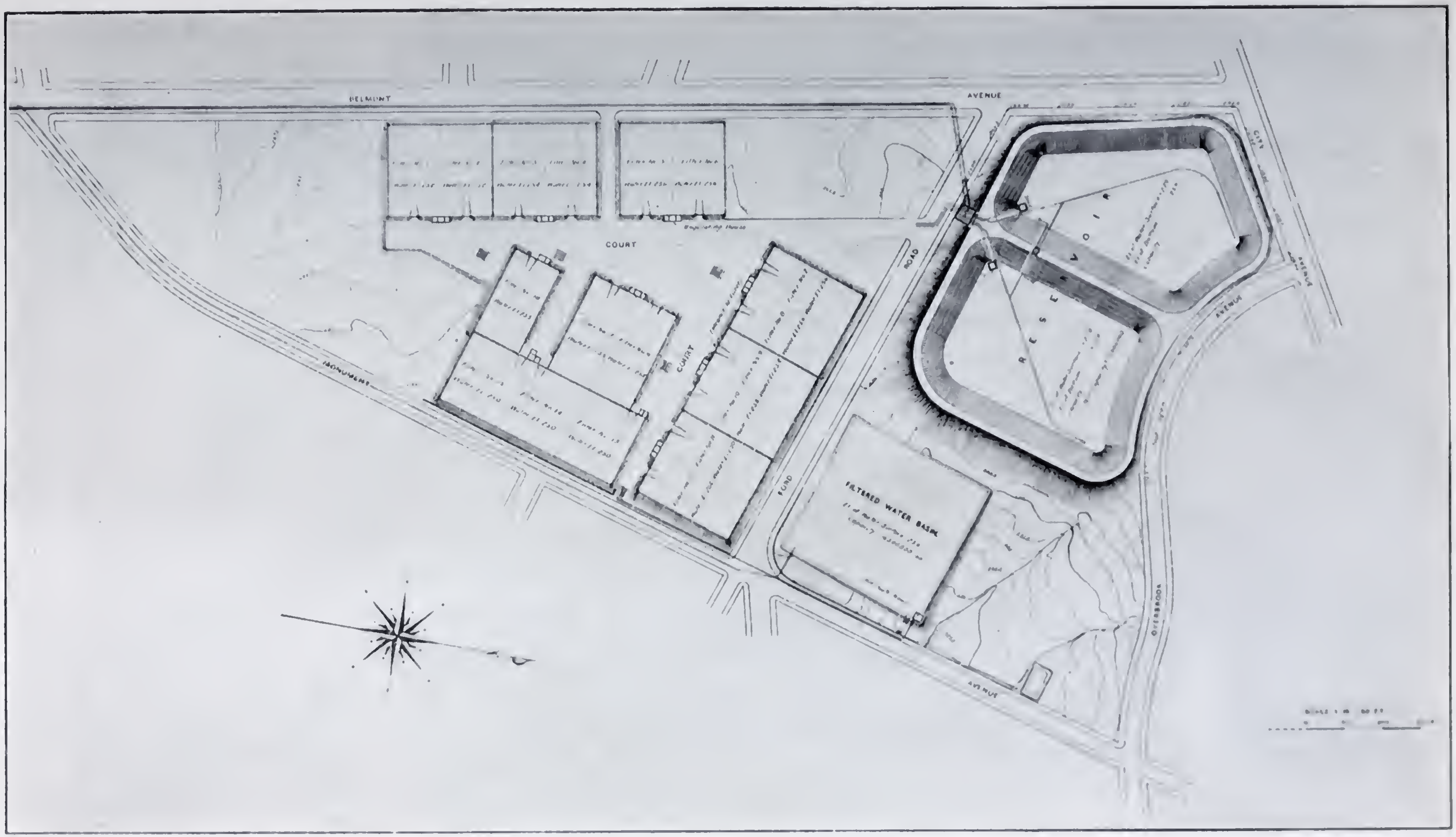

FIG. 3.—BELMONT FILTERS AND RESERVOIR.

tion, as will be noticed, is in solid rock, sometimes as hard as quartz. While rock was shown by the diamond drill borings to constitute a large part of the excavation, it was not thought that so much blasting as was really required would be necessary in moving the material. All the excavation for both divisions of the reservoir is now completed, the puddle lining placed and rolled over part of the floor of the east division, and with the advent of spring the leveling up of the floor of the west division, and trimming of all the inside slopes,

Fig. 4.—Belmont Reservoir Excavation—West Basin.

will be commenced with a view to the early completion of this detail of the work.

Figure 5 shows in detail the method of paving the floor and slopes of the reservoir. After the floor has been brought to sub-grade, by excavation and filling with concrete and rough stones in mortar, a layer of clay puddle 18 inches thick is placed and rolled in 6-inch layers over the floor; above this is placed an 8-inch paving of concrete rammed in place, and over this a layer or sheet of asphaltic mastic consisting of Neuchâtel or other equal imported rock asphalt, with Bermudez asphalt as a flux and binder, mixed with granolithic grit.

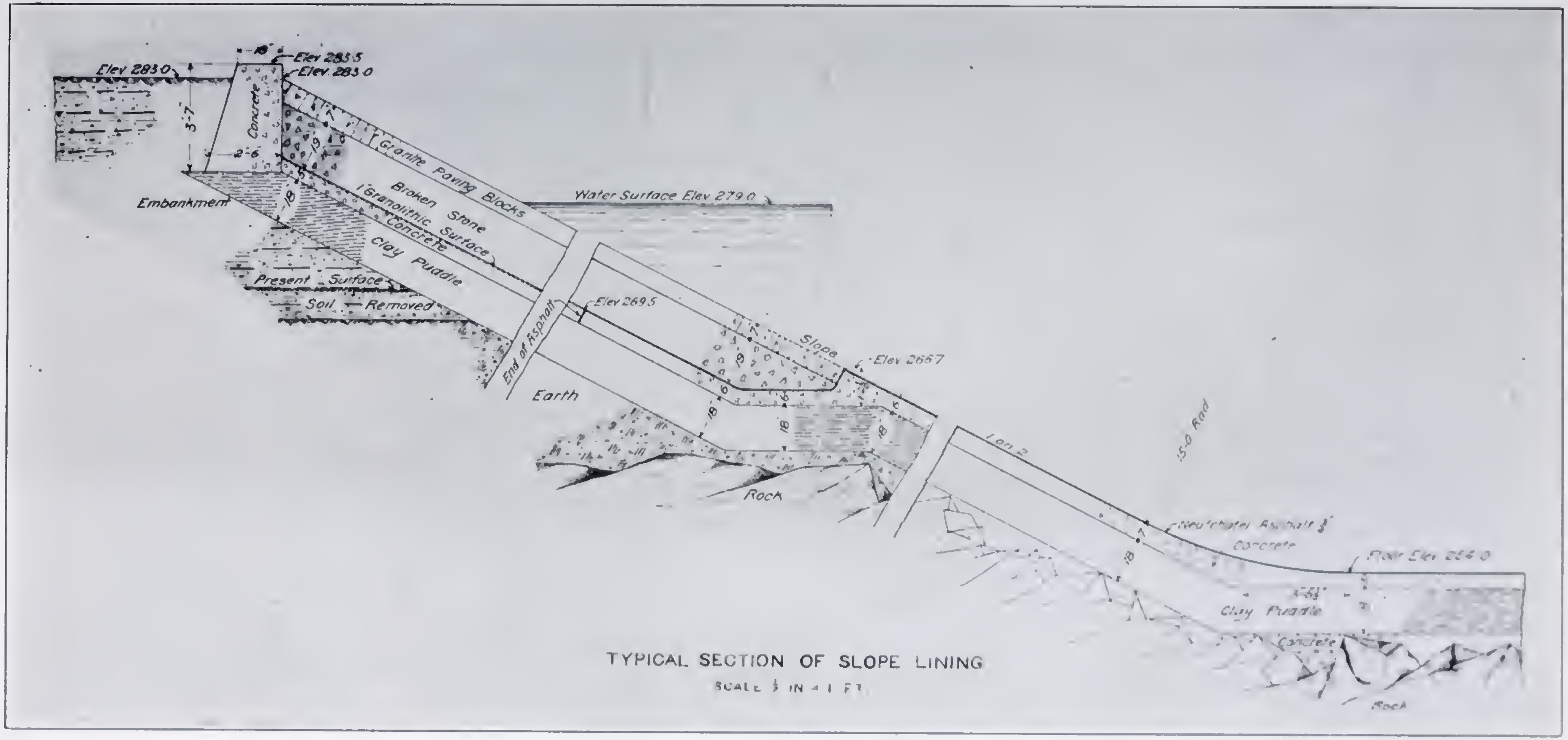

FIG. 5.—BELMONT RESERVOIR—SECTIONS OF EMBANKMENT AND LINING.

The proportions set out in the specifications are 70 parts by weight of rock asphalt, 10 parts of Bermudez asphalt, and 20 parts of sharp grit and sand. These proportions may be varied, if the city should deem it advisable, to secure a water-tight lining. The thickness of puddle is the same on the slope as on the floor, but the concrete paving varies from a thickness of 7 inches at the bottom of the slope to 6 inches at the berm, from which point to the top of the slope the thickness is continued as 6 inches. Above the berm is shown a dry paving of Belgian blocks, pavement size, backed with broken stone.

Fig. 6.—Belmont Reservoir—Inlet and Outlet Gate House.

In the original plans this was thought to be necessary as a protection from the frost to the puddle; but when the studies were being made for the paving of the slopes of the Oak Lane reservoir, it was not thought essential to repeat this construction, and it has been about decided to omit it in the Belmont basins as a superfluous detail.

The clay puddle used throughout the work, except at Lower Roxborough, consists of equal parts of a strong Delaware or New Jersey clay, Swedeland clay, and graded gravel or broken stone, mixed and wetted in a horizontal screw puddle pug mill, and rolled with

horse and steam rollers on the floor, and with horse rollers on the slopes, in thin layers. The imperviousness of this puddle is such that when placed in a 12-inch layer under the concrete inverts (6 inches thick at the center) of the filters at Upper Roxborough and at Belmont, some of the filters showed no leakage after weeks of test, the level of the water being taken with a hook gauge and proper corrections being made for the weather conditions.

Figure 6 shows the gate house of the Belmont reservoirs, which contains, with the exception of one 48-inch gate in the division em-

Fig. 7.—Belmont Filters—Filter No. 1.

bankment, all the gates to control the flow of water into either compartment of the reservoir, and draw the subsided water through either effluent pipe from the reservoir to the preliminary filters, or, if it should be so desired, draw it to the plain sand filters. Thirteen 48-inch stop-valves are located in the basement or pit of the gate house.

Figure 7 shows the concrete piers of one of the Belmont filters, which were made as separate monoliths in two sections and set on the pier seats with the aid of a derrick. All other piers at Belmont, Roxborough, and Torresdale were built, or are being built, in place.

2

From the subsiding basins the water will flow by gravity to the preliminary filters to be located in the angle between Belmont Avenue and Ford Road. The plans for these filters are now well advanced and the work will be put under contract early this season. These are being planned for an immediate capacity of 40,000,000 gallons per day, to be increased by additions of other filters to keep pace with the increasing consumption of water from this station. From the preliminary filters the water will flow by gravity to the plain sand filters, thence by gravity to the clear-water basin, from which, until the consumption has increased to more than 40,000,000 gallons per day, the filtered water will flow into the West Philadelphia distribution system through a 48-inch cast-iron main laid in Monument Avenue and Belmont Avenue to an intersection with the present rising mains from the Belmont pumping station at Belmont and Montgomery Avenues.

After the Belmont filters have been started, the old 30-inch and 36-inch rising mains will be closed at the points where they cross Belmont Avenue, in a manner to effectually prevent a transfer of unfiltered water to that portion of the pipes laid west of the intersection with the new 48-inch pipe in Belmont Avenue supplying filtered water to the system.

From the intersection of the 48-inch filtered water main with the old rising mains the distribution of filtered water will be effected through the present system of mains.

The service at Belmont will embrace but one lift of the water from the Schuylkill River at Belmont pumping station to the subsiding reservoirs.

The elevations of the Belmont works are as follows:

Flow line, subsiding reservoirs, ...	279.00	C. D
Flow line, preliminary filters, ...	267.00	"
Water-level, filters Nos. 1 and 2, ...	250.00	"
Water-level, filters Nos. 3 and 4, ...	252.00	"
Water-level, filters Nos. 5, 6, 7, and 8, ...	254.00	"
Water-level, filters Nos. 9, 10, 16, 17, and 18, ...	251.00	"
Water-level, filters Nos. 11, 12, 13, 14, and 15, ...	248.00	"
Flow line, clear-water basin, ...	239.00	"

The elevation of the flow line of George's Hill reservoir is 212.00 C. D., or 27 feet below the flow line of the new Belmont clear-water basin.

The varying elevations of the filters is due to the topography of

the land taken. The ideal arrangement, of course, is filters at uniform elevations, as at Upper Roxborough and Torresdale; but a balancing of the fixed charges on the extra cost of constructing the Belmont filters at uniform elevation against the money value of the extra head pumped against, represented by the difference between the highest and lowest filters in the series,—viz., 6 feet,—indicated the least cost in adapting, with some limitations, the filters to the natural topography of the site.

Filters Nos. 11, 12, 13, 14, and 15 are partly or wholly built on filled ground, rolled in thin layers with a steam roller weighing 3333 pounds per foot width of roller, while all other filters are built entirely in excavation. A careful balancing of cut and fill admitted of a reduction of the pumping head actually lost by the terracing of the filters to 6 feet.

The clear-water basin at Belmont has a capacity of 16,500,000 gallons with a depth of 15 feet. The subsiding reservoirs have a capacity of 72,000,000 gallons with a depth of 25 feet. All filters at Belmont, and all other stations, have a depth of 9 feet 9 inches from the center of the invert in the floor to the spring line of the arched vaulting, with a rise of 3 feet to the arch.

Upper Roxborough Filters.

Figure 8 shows in plan the Upper Roxborough filters. These works comprise eight $\frac{3}{4}$-acre filters, measured at the sand line, and a clear-water basin of 8,000,000 gallons capacity. The filters are all at uniform elevation—viz., 419.00 C. D. at the high-water line. The general plans contemplate an addition of four filters to the rear or north of filters Nos. 1, 2, 3, and 4, and, should it be demanded in the future, five or six more filters can be located north of filters Nos. 7 to 12, on the property acquired by the city. It is not thought that the consumption of water from this station will require an addition to the filters for the next ten or fifteen years, but the size and arrangement of raw-water supply-pipes, and filtered effluents, have been based on the maximum work of the station.

It has been stated that the Upper Roxborough filters are expected to work entirely with subsided water, which, with the early capacity of the works, will represent from seven to ten days' subsidence in the Upper Roxborough reservoirs, and which it is thought will admit of working these filters at a 4,500,000-gallon rate per acre without preliminary filtration. In due time, as the consumption of filtered

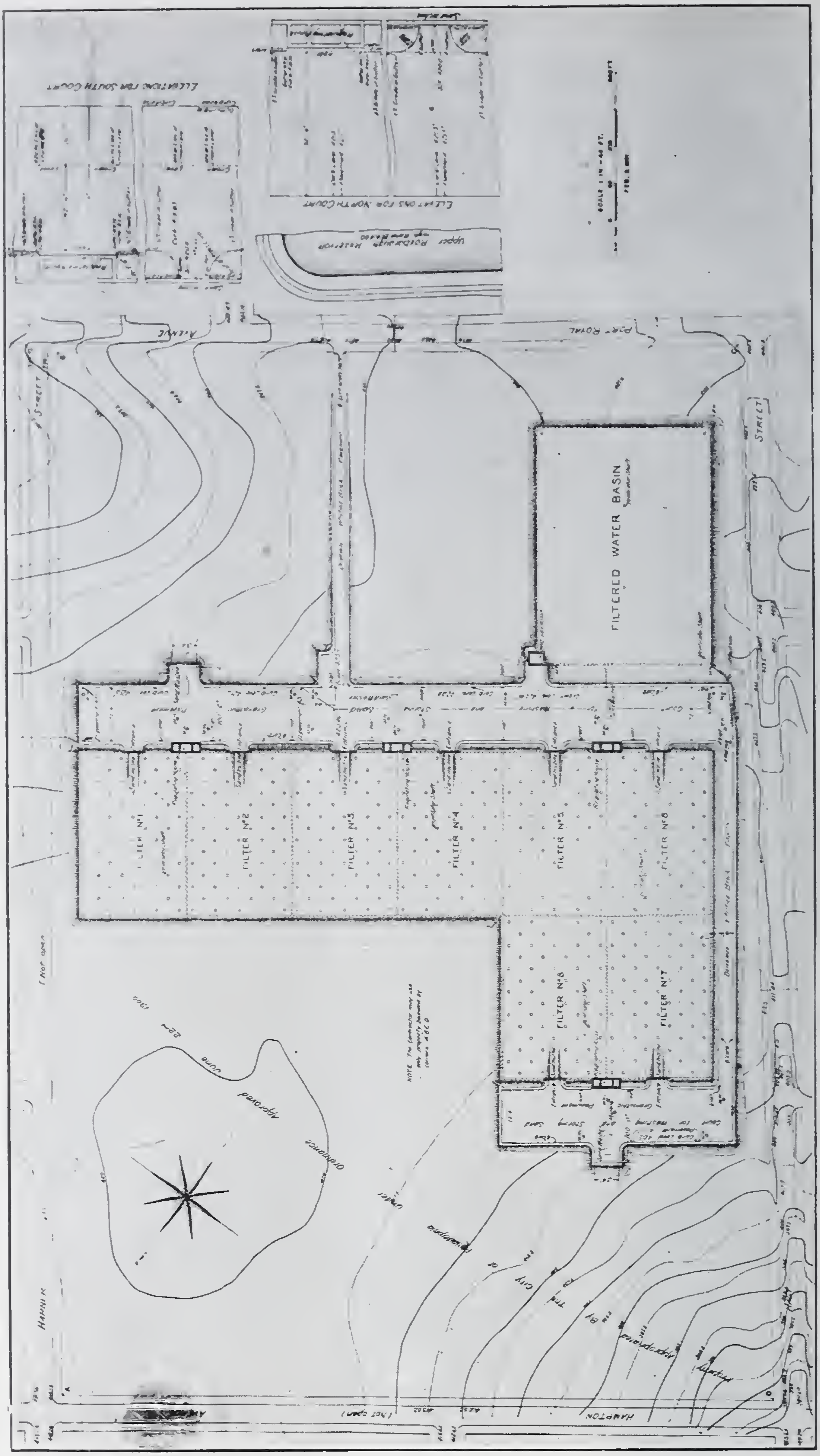

FIG. 8.—UPPER ROXBOROUGH FILTERS.

water increases, it will doubtless be found advisable and more economical to construct preliminary filters as an auxiliary to the Upper Roxborough station, and raise the rate of filtration to 6,000,000 gallons per acre per day rather than add to the number of plain sand filters.

Figure 9 shows the regulator house for two of the Upper Roxborough filters, which is typical of the regulator houses of all the filters, except that each filter at Lower Roxborough, as well as filters Nos. 13 and 18 at Belmont, has a separate house.

In the double house shown in plan by figure 10, there is a central dry chamber in which are placed the pipes and valves which control

Fig. 9.—Upper Roxborough Filters—Filter Entrance and Regulator House.

the flow of water into the filter, and for the drainage of water from above the sand-level, when the filter is taken out of service for scraping, and two wet chambers, one for each filter of the pair, which contains the effluent regulating and measuring weir, the pipes and valves to disconnect the filter from the main effluent pipe and to refill the filter after sand scraping, from below. The wet chambers also contain pipes and valves for the complete drainage of the filter. The floating weir used in the filters is modeled after that used by Mr. Lindley

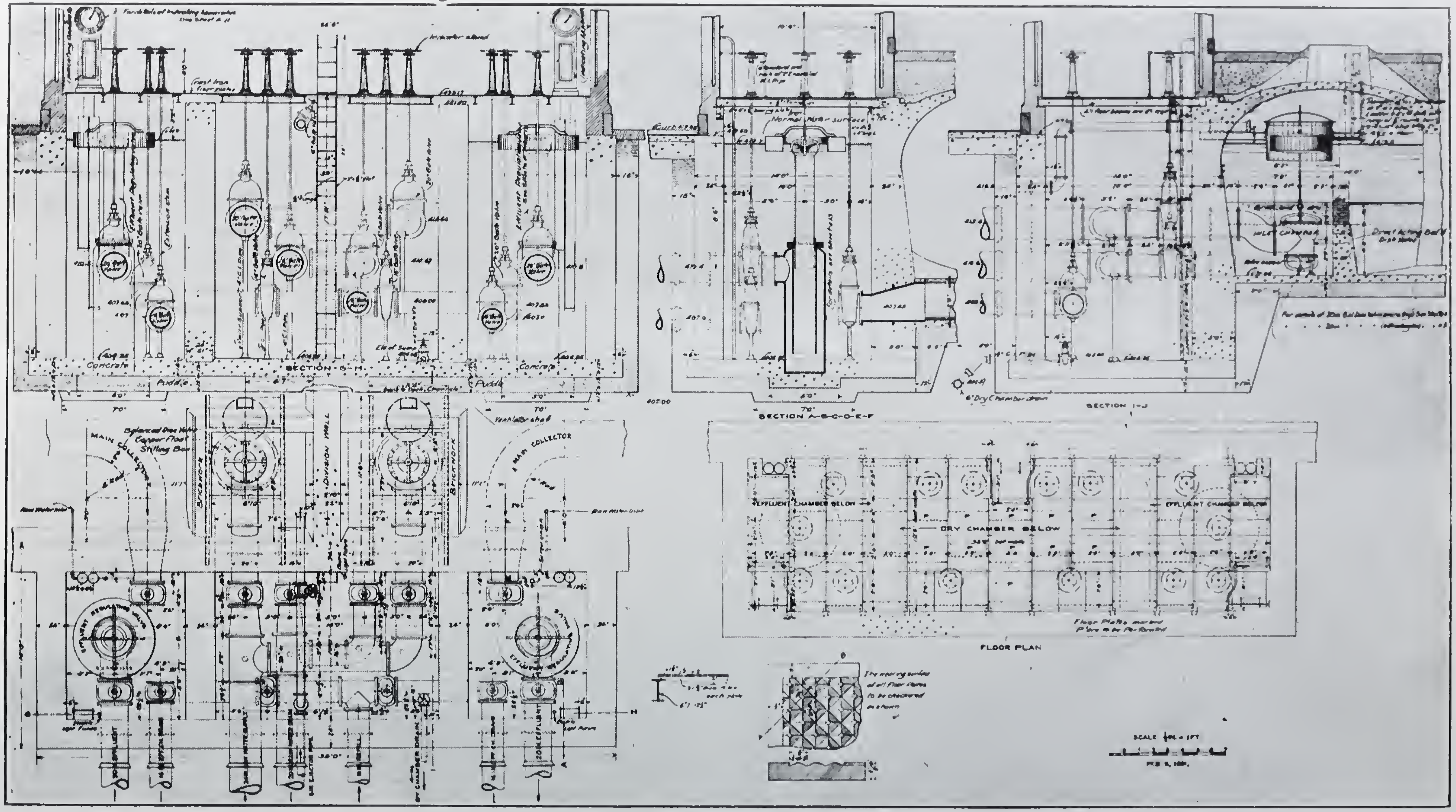

FIG. 10.—UPPER ROXBOROUGH FILTERS—REGULATOR AND INLET CHAMBERS.

in the filters of Warsaw, but is made adjustable to regulate the flow from the filter without changing the position of the copper float.

The filter entrance shown in figure 10 is typical of all the filters. Each entrance is provided with two inclined sand runs for wheeling the washed sand from the courts back into the filters. The entrance is closed with double doors, which in summer-time are usually left open to aid in the ventilation of the filters. In winter, when the temperature of the air is 32° F. or less, the doors are always closed when the sand beds are laid dry, to prevent freezing at the surface of the sand.

Lower Roxborough Filters.

Figure 11 shows in plan the filters at Lower Roxborough which have been in service since last August. This station contains five ½-acre filters, measured at the sand line, and a clear-water basin of 3,000,000 gallons capacity. The present filtering capacity is from 6,000,000 to 7,000,000 gallons per day, which will be raised to 12,000,000 gallons per day when the preliminary filters now under construction have been completed and started in service.

Figure 12 shows the puddle lining under the concrete floor and back of the side and end walls. The inverts constituting the floor sections are 6 inches thick at the center and 14 inches thick at the pier seats. The concrete was made and placed without any special precautions to insure water-tightness, reliance being had entirely on the puddle. Considering that these tanks will be filled only with filtered water after the sand and underdrains have been placed, the structure must be made water-tight when built, or perhaps it will never by use become tight. Certain of the filters show no leakage, and the maximum allowable leakage on a ¾-acre filter is 1000 gallons in twenty-four hours, which represents from 0.022 to 0.030 per cent. of the daily capacity of the filter. Data on the water-tightness of structures of this character are not forthcoming, but it was thought in this instance that a leakage of a concrete tank 200 feet long, 150 feet wide, and 9 feet deep, surrounded by a lining of puddle from 12 to 18 inches thick, not in excess of 0.04 per cent. of the volume of water daily passing through, was allowable. Absolute water-tightness can be had with a glass bottle or a pressed-tin cup, but it is very difficult to insure in large masonry tanks. The puddle was placed over the entire floor of all filters, regulator houses, and water basins, and carried up outside the side and end walls for a height 1 foot above the water line.

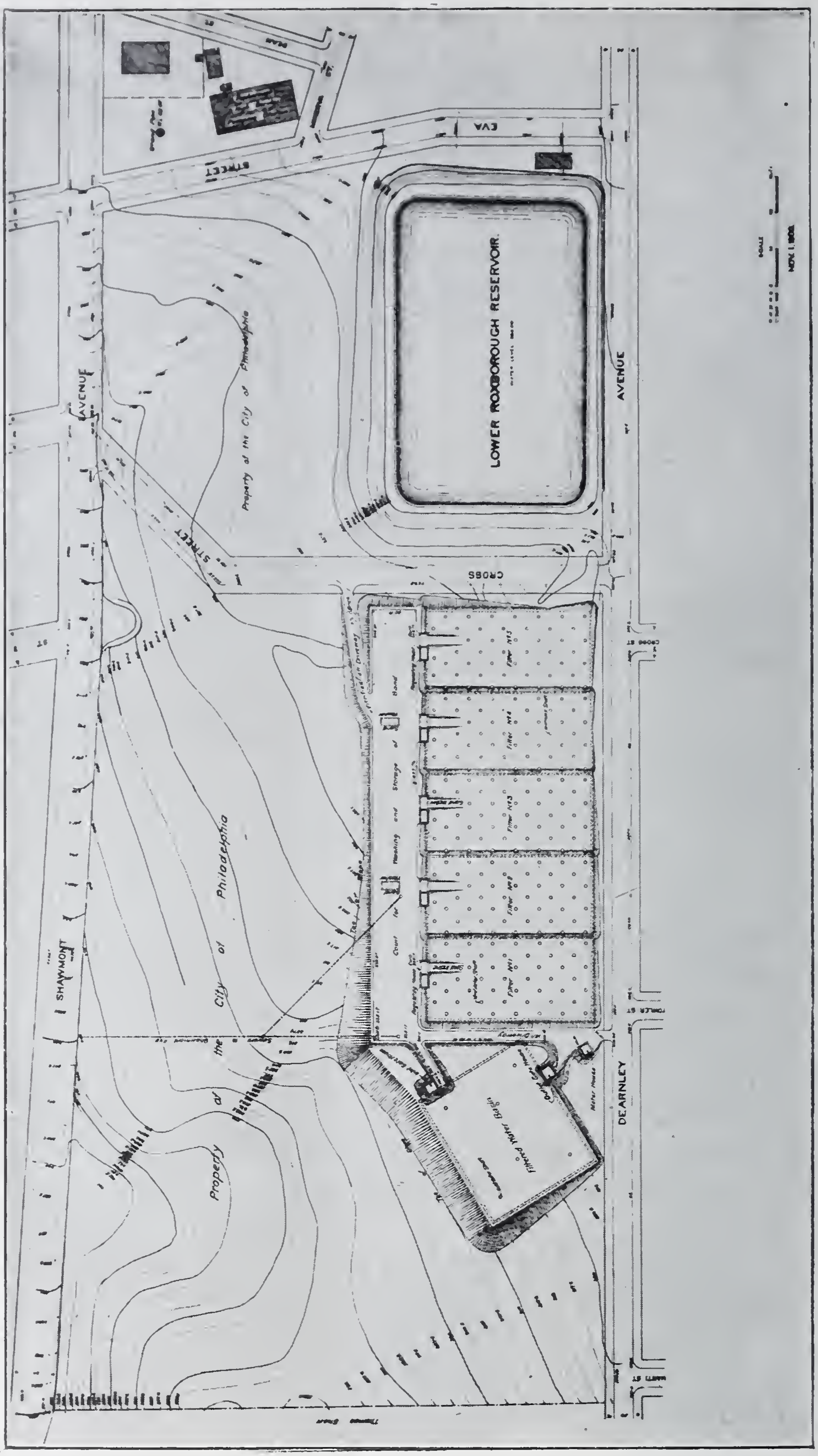

FIG. 11.—LOWER ROXBOROUGH FILTERS.

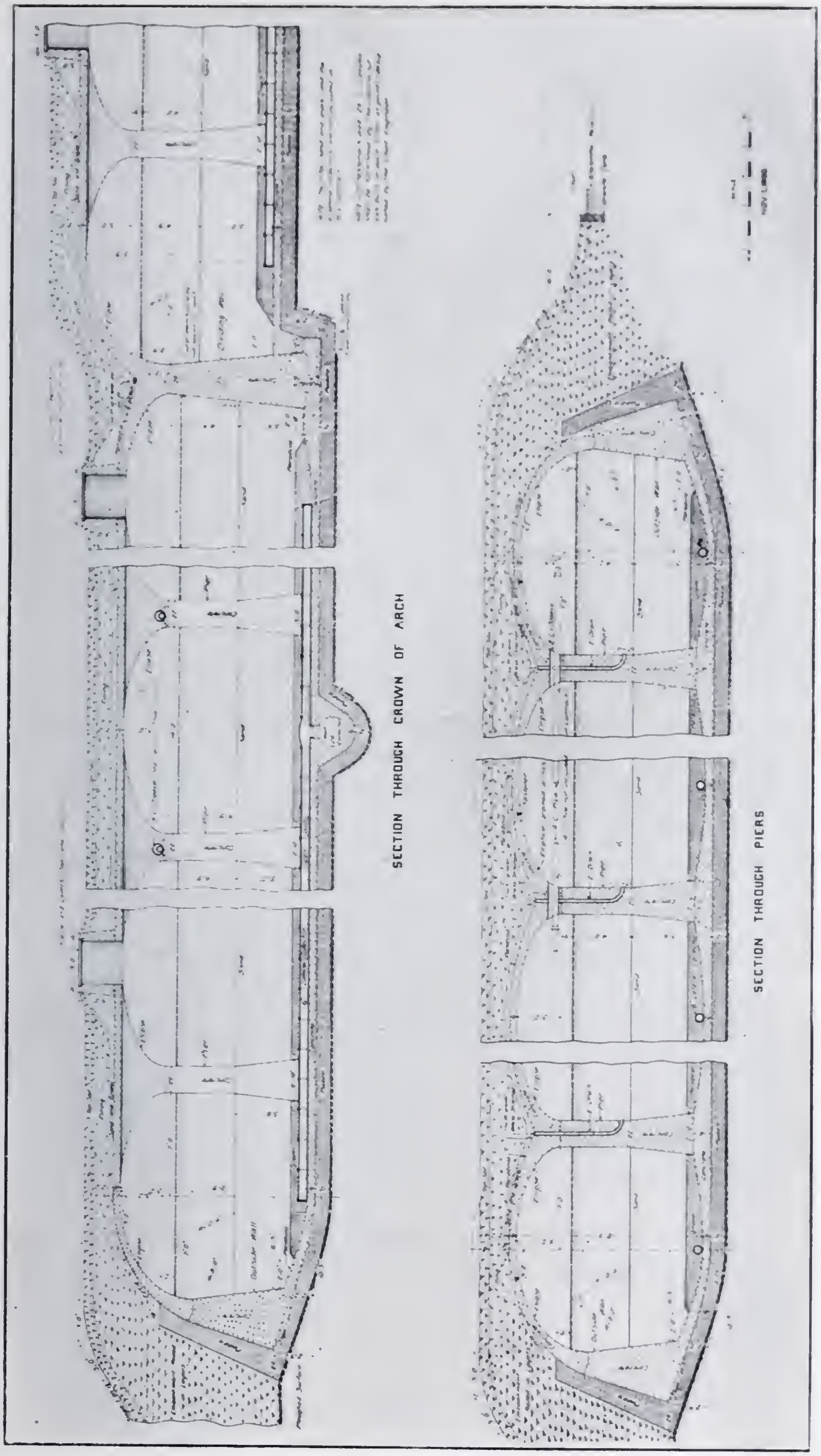

Fig. 12.—Lower Roxborough Filters—Sections of Filters.

Over the arches of the filters is placed a filling 3 feet deep, partly of gravel or broken stone and partly of earth, covered with a layer of top soil, grass seeded to form a turf. Water collected on the earth covering of a filter percolates through the material and finally passes down the side of the concrete pier through a small opening left in the roof. Over the clear-water basins the depressions between the arches are filled and rolled level with the top of the arches, with clay puddle, above which is placed a covering of earth rolled in place, top-soiled and seeded. Water absorbed by the filling is carried off by a system of subsoil drains.

The two bottles on the President's desk show the character of water flowing to-day in the Schuylkill River at the pumping station and the kind of water now coming from the Lower Roxborough filters. The raw water contains a turbidity of 140 parts per million by the silica standard and a bacterial content of 25,000 per cubic centimeter, while the filtered water contains 2 parts turbidity by the silica standard and 45 bacteria per cubic centimeter.

Preliminary Filters—Lower Roxborough.

Two and one-half years' experience at the Spring Garden and Harrison Mansion testing stations, on the Schuylkill and Delaware River waters, demonstrated the advantage—in fact, the necessity—of preliminary treatment of the raw river or subsided water by rough filtration, through beds of coarse material, gravel or sand, at rates varying from 40,000,000 to 120,000,000 gallons per day per acre of filtering area, before the water is applied to the plain sand filters. The advantages of preliminary filtration are threefold:

1. It prolongs the life of the filter and increases the yield between scrapings from 50 to 200 per cent. over the plain sand filter working only with subsided water.

2. It makes it possible to operate the plain sand filter at rates twice that accepted abroad as the proper rate; viz., to raise the rate from 3,000,000 gallons per acre to 6,000,000 gallons per acre per day.

3. It insures a uniformly better quality of effluent from the filters. The operation of plain sand filters with a preliminary roughing filter is not a new thought. Such filters working on the water from the River Maas have been used at Schiedam, Holland, for more than seventeen years; but the system used there is not quite like that which we have been working with here on the Schuylkill and Delaware

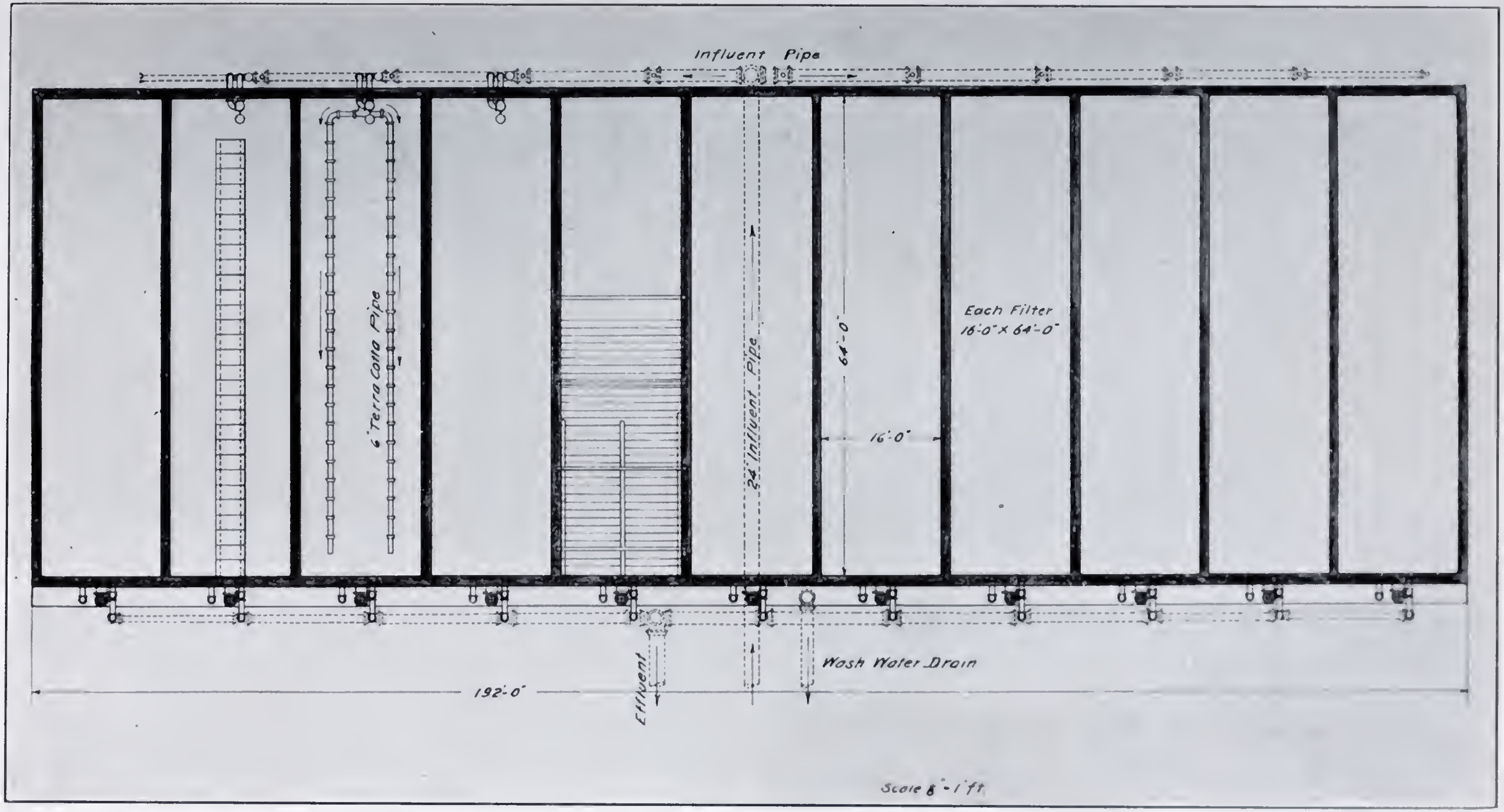

Fig. 13.—Plan of Preliminary Filters, Lower Roxborough.

River waters. At Schiedam one preliminary filter may be required to supply water to three final filters, or two preliminary filters may be in service and supplying water to three final filters. The final plain sand filters have been worked at rates as high as 5,000,000 United States gallons of water per acre per day, and the maximum yield of a preliminary filter has been 15,000,000 United States gallons per acre per day. Ordinarily the preliminary filters work at from one and one-half to twice the rate of the final filters.

In proportions and construction the "vor" filter and "sand" filter at Schiedam are alike, except the former is filled with coarser sand.

It should be understood that the River Maas is tidal at Schiedam, and the conditions there resemble somewhat those that will prevail at the Torresdale filters on the Delaware River.

At Lower Roxborough the preliminary filters (Fig. 13) will consist of eleven concrete tanks 16 feet wide, 64 feet long, 5 feet 6 inches deep, inside measurements. When all the filters are in service, the acre rate will be about 40,000,000 gallons per day, and with eight filters in service the acre rate will be about 60,000,000 gallons per day.

These tanks (Fig. 14) will contain a layer of coarse gravel at the bottom about 5 inches thick; above this a layer of crushed and screened furnace slag, particles ranging from $1\frac{1}{2}$ inches to $\frac{3}{4}$ inch in diameter, about 10 inches thick, and above this a layer of slag particles $\frac{3}{4}$ to $\frac{1}{4}$ inch diameter, 24 inches thick, and above this a layer of 9 inches compressed sponge as a mattress pressed down on the slag. The water will pass from below upward and is drawn from the tanks at the top. During the more turbid periods of the river water the granular material and the mattress are partially freed from the collected mud by stopping the flow and allowing the water contained in the tank to drain off. From four to five times a year the mattress is taken out, washed in a machine, and replaced. Once or twice each year the granular material requires flushing with a strong hose-stream played through a nozzle.

The preliminary filters will do in a short time what would require a very great, and in most cases inadmissible, length of time with settling basins. Thus, within a very few hours there can be removed from the Schuylkill and Delaware River waters by preliminary filters an amount of suspended matter which would require from three to four weeks to remove by storage of the water in sedimentation basins,

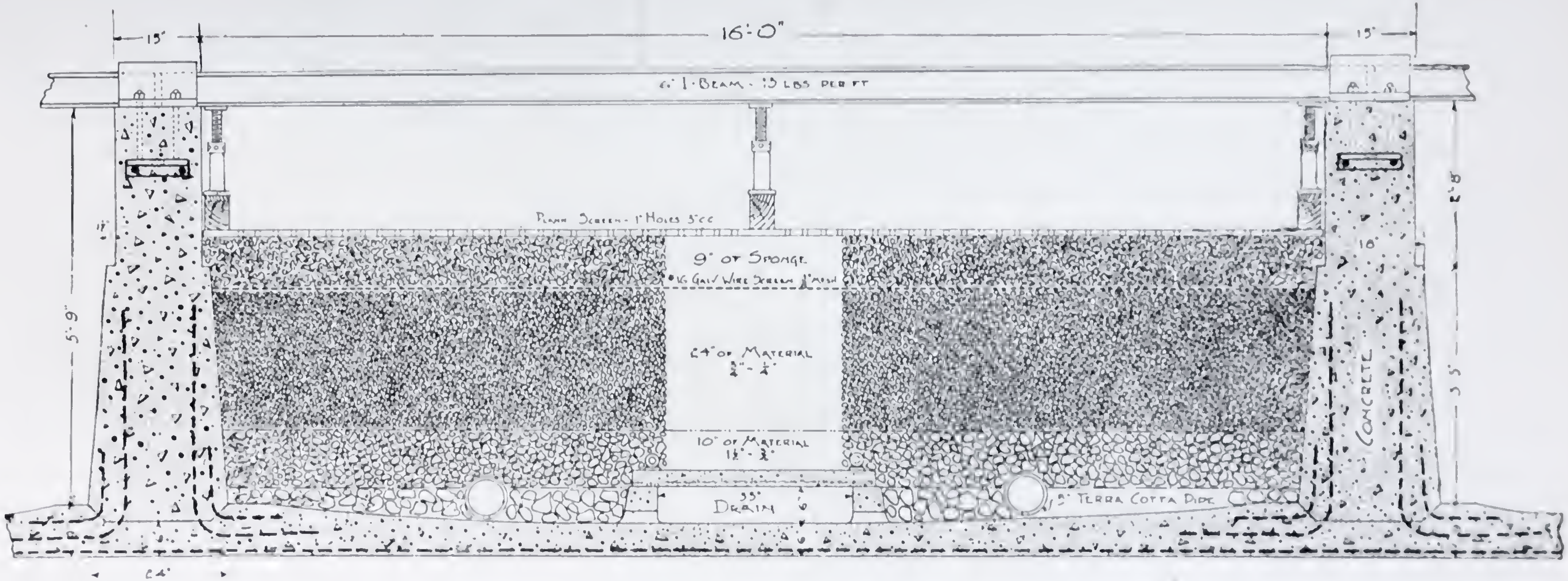

Fig. 14.—Cross-section through Preliminary Filter, Lower Roxborough.

and a comparison of the cost of the two methods of preparing water for plain sand filters indicates that $1,000,000 in preliminary filters will accomplish as much as $20,000,000 in settling basins, without considering the larger cost within the city limits of land for the latter structures.

Upon the completion of the preliminary filters at Lower Roxborough about 4,000,000 gallons per day will go to Manayunk and 8,000,000 gallons to Germantown.

Referring to the clear-water basin at Lower Roxborough and the other stations, these are not intended for storage, but to compensate for the varying rates of hourly consumption during the day. The filters will be operated at nearly uniform rate, but the consumption of water, of course, will vary from hour to hour throughout the day.

Torresdale Filters.

Figure 15 shows in plan the first installation of fifty-five filters at the Torresdale station. As will be noticed, these works consist of five banks of eleven filters each, with a wide court between for the sand washers and temporary storage of washed sand. North of the upper bank of filters ten other filters are planned which will provide for a part of the present Queen Lane consumption and increase the present capacity of these works to 248,000,000 gallons per day.

The present contract, known as contract No. 25, embraces the first fifty-five filters, the clear-water basin, all sewers, main conduits, and supply pipes proportioned for the future extensions of this station.

The additional items required to complete the Torresdale filters are principally the low-service pumping station and machinery, preliminary filters, sand washers and pumps, electric lighting system, coal-handling machinery and pockets, and a spur track from the New York division of the Pennsylvania Railroad.

The sewerage system for this station is planned to care for the drainage from a considerable area of tributary property in addition to the overflow and waste from the filters and sand washers and the sewage collected at the station. The outfall is in Pennypack Creek, which empties into the Delaware River, at the south line of the property taken for construction of the filters and their auxiliary works.

In the early discussion of the filters at Torresdale a sewage disposal works, capable of dealing with the sewage of a semi-urban population of 45,000, was considered as an essential, when the territory draining into the Pennypack Creek begins to grow in population, to

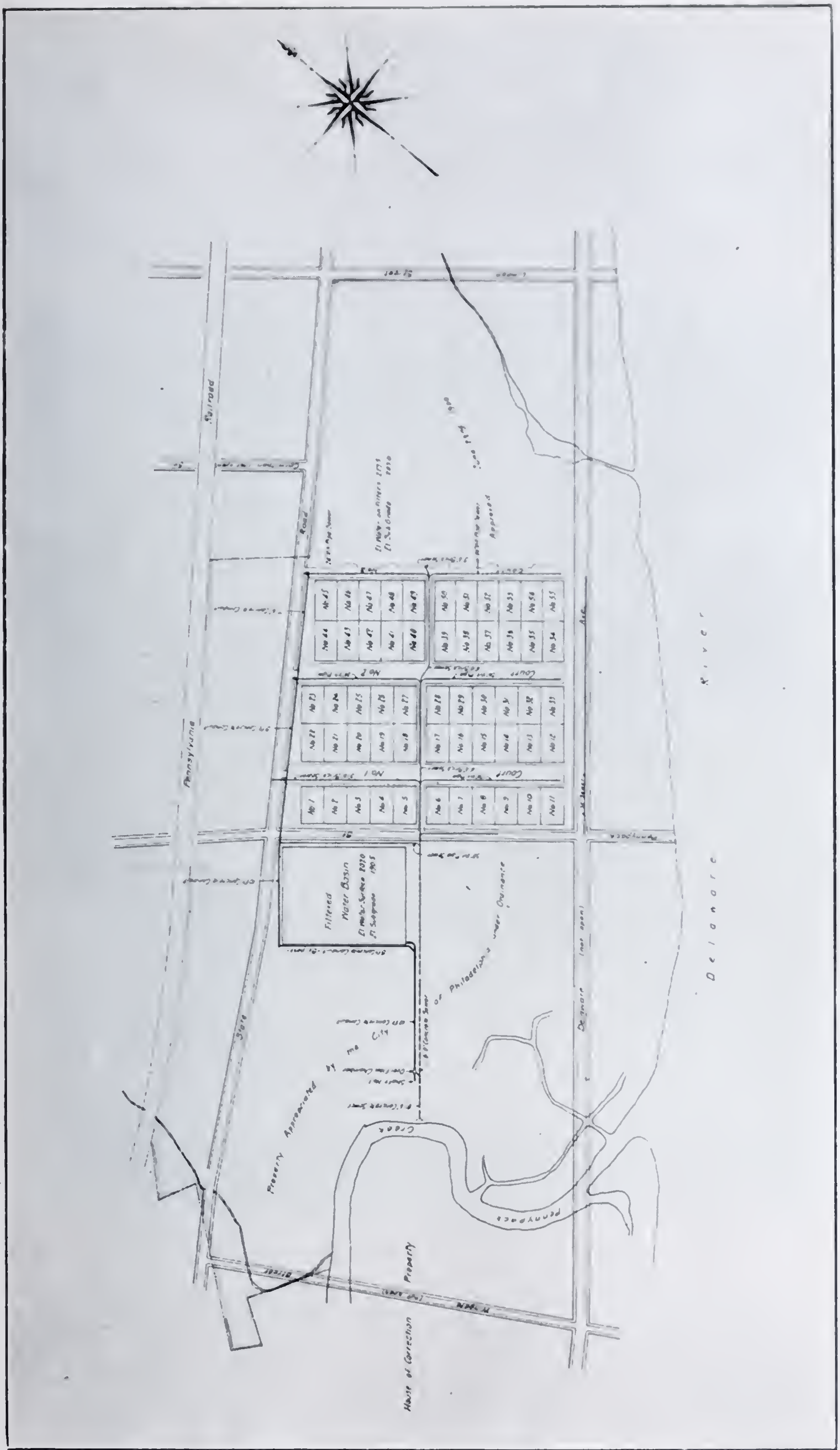

FIG. 15.—TORRESDALE FILTERS.

guard against the delivery of fresh sewage too near the intake for the filters. No steps have been taken to reduce the sewage disposal works to a definite plan, and doubtless the time is far distant when these will be needed.

Figure 16 shows a section of the main conduit placed at the west

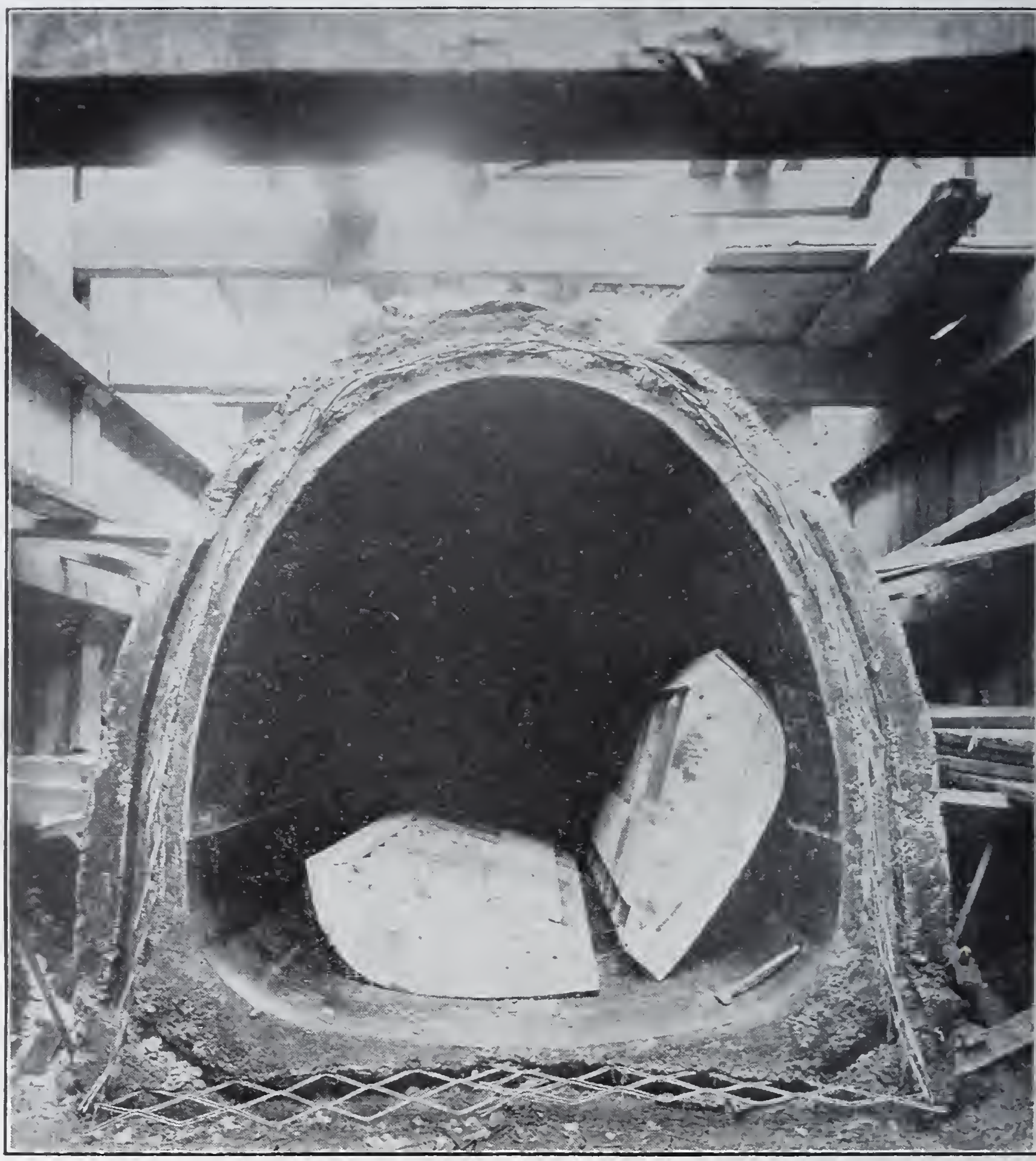

Fig. 16.—Torresdale Filters—Section of Main Conduit.

end of the filters to conduct the water from the filters to the clear-water basin. This conduit, varying from 9 feet diameter at the clear-water basin to 7 feet 6 inches diameter at court No. 3, is constructed of concrete, reinforced with expanded metal, and is supplied with water from the several groups of filters through a cast-iron main varying from 60

inches diameter at the conduit to 24 inches diameter at the most remote filter of each group. One of these cast-iron compound mains lies on each side of each court and serves one group of eleven filters. This conduit is typical in form and materials of construction of all the large conduits at this station.

The general elevations of the Torresdale filters and the Torresdale

FIG. 17.—TORRESDALE FILTERS—EXCAVATION FOR CLEAR-WATER BASIN.

conduit, referred to Torresdale datum, which is 200 feet below city datum, are here given:

Flow line of all filters,	215.00	T. D.
Flow line of clear-water basin,	207.00	"
Head of shaft No. 1,	216.46	"
Center of conduit, shaft No. 1,	104.32	"
Center of conduit, shaft No. 11,	114.66	"
Head of shaft No. 11,	216.46	"
Center of conduit from clear-water basin to shaft No. 1, where it connects with the shaft,	186.50	"

The clear-water basin is wholly in excavation, and figure 17 shows the steam shovel at work excavating materials at about sub-grade. The material is chiefly river deposit of mixed gravel and sand. At

some spots the material, when excavated to sub-grade, has been found very unstable and not adapted to receive the floor loads of the basin when completed, which, under the piers, will reach about four tons per square foot. To remedy this condition the soft material has been excavated for depths ranging from a few inches to 3 feet or more, and replaced with layers of sand and gravel, and boulders rolled in place, to create a hard, unyielding floor upon which the inverts of the floor will be laid. The least elevation of the base of these excavated portions below sub-grade is about 187.50, or more than 5 feet below mean low water in the Delaware River and 3 feet below extreme low water. The artificial foundation thus made is as solid after rolling as the natural materials.

At Belmont, where soft spots were found in the materials of the clear-water basin at sub-grade for the floor, layers of stone spawls were brought on and rolled in place, and to avoid possible injurious settlement under the piers which carry the concrete roof arches and load of earth filling, excavations were made to depths of 5 and 6 feet below sub-grade, a timber grillage placed, and concrete sub-piers carried up to sub-grade; over the piers, as well as elsewhere throughout the floor, a 12-inch layer of clay puddle was rolled in 6-inch (finished) layers, in order that the compression of the puddle by the floor, roof, and water loads should be as nearly as possible uniform over the whole area.

Torresdale Conduit.

The water from the clear-water basin of the Torresdale filters flows through a concrete conduit of horseshoe section, equal in area to a circle 10 feet diameter, to shaft No. 1 of the Torresdale conduit, and down shaft No. 1, through the tunnel, and up shaft No. 11 at the Lardner's Point pumping station, to the pump wells in the engine-houses. The two end shafts and the tunnel constitute a large inverted siphon blasted through the gneiss rock and lined with stretcher brick (Fig. 18). The general depth of the tunnel part of the siphon is about 100 feet below mean ground-level. Shaft No. 1, shown on figures 15 and 19, is uniformly 10 feet 6 inches diameter from top to bottom (Fig. 19). While shaft No. 11 (Fig. 20) has the same diameter as No. 1 from the tunnel to a point about 50 feet below ground-level, and from this elevation to the head of the shaft, 10 feet above ground-level, the diameter is enlarged to 21 feet to reduce the velocity of the water before its flow is changed at right angles, to enter the conduit which connects the effluent shaft with the pump wells at Lardner's

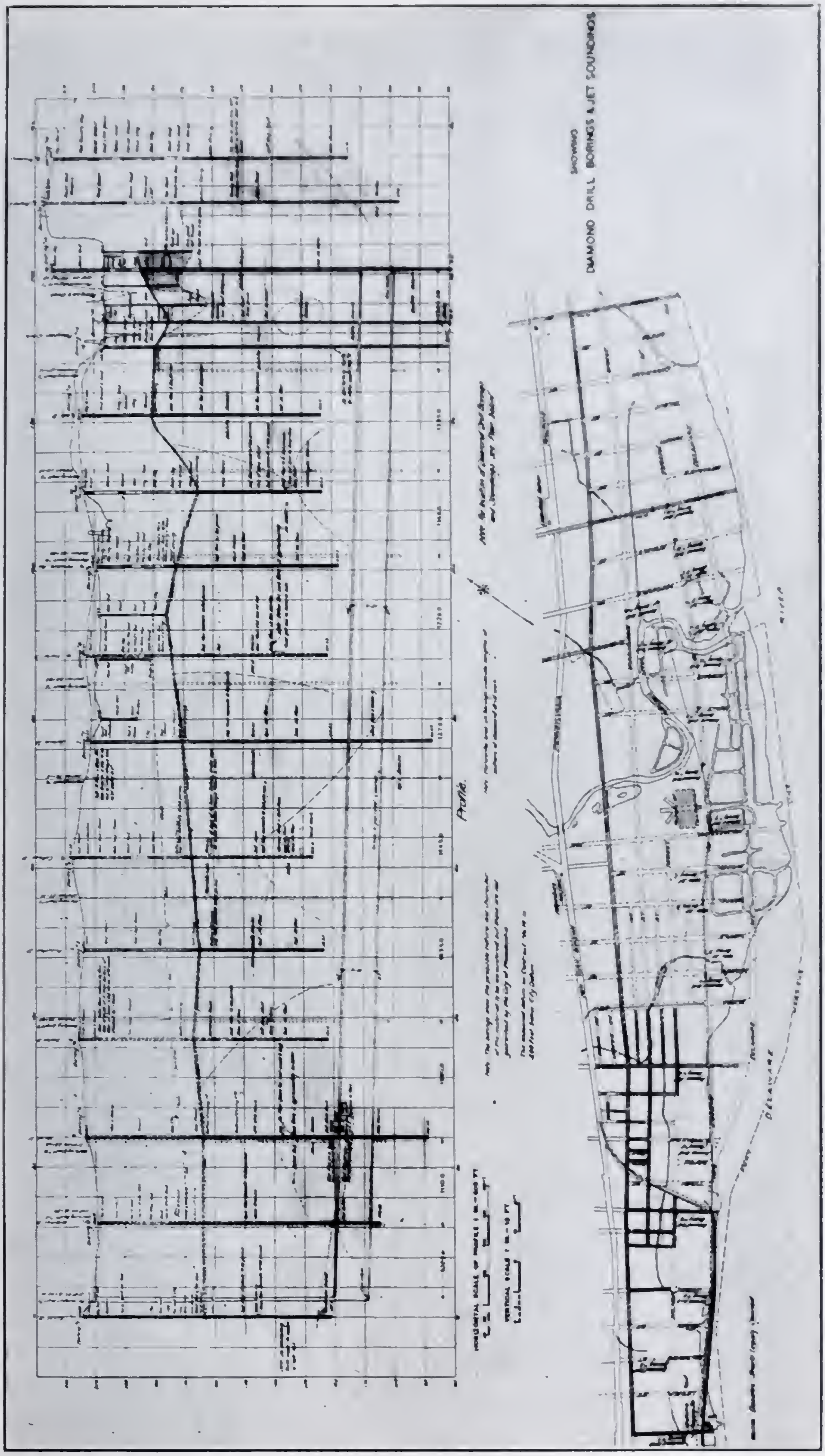

Fig. 18.—Torresdale Conduit—Plan and Profile.

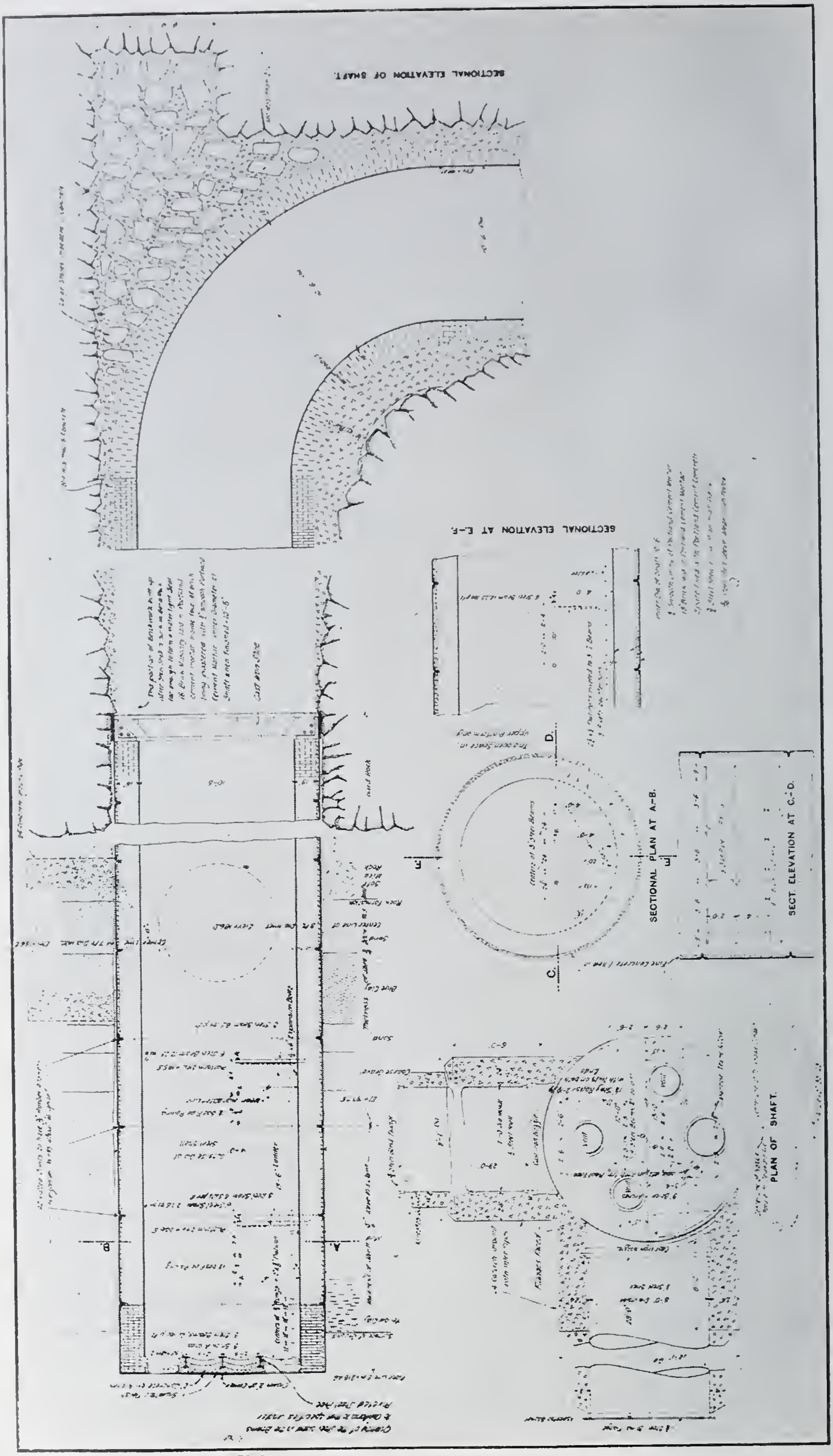

Fig. 19.—Torresdale Conduit—Shaft No. 1.

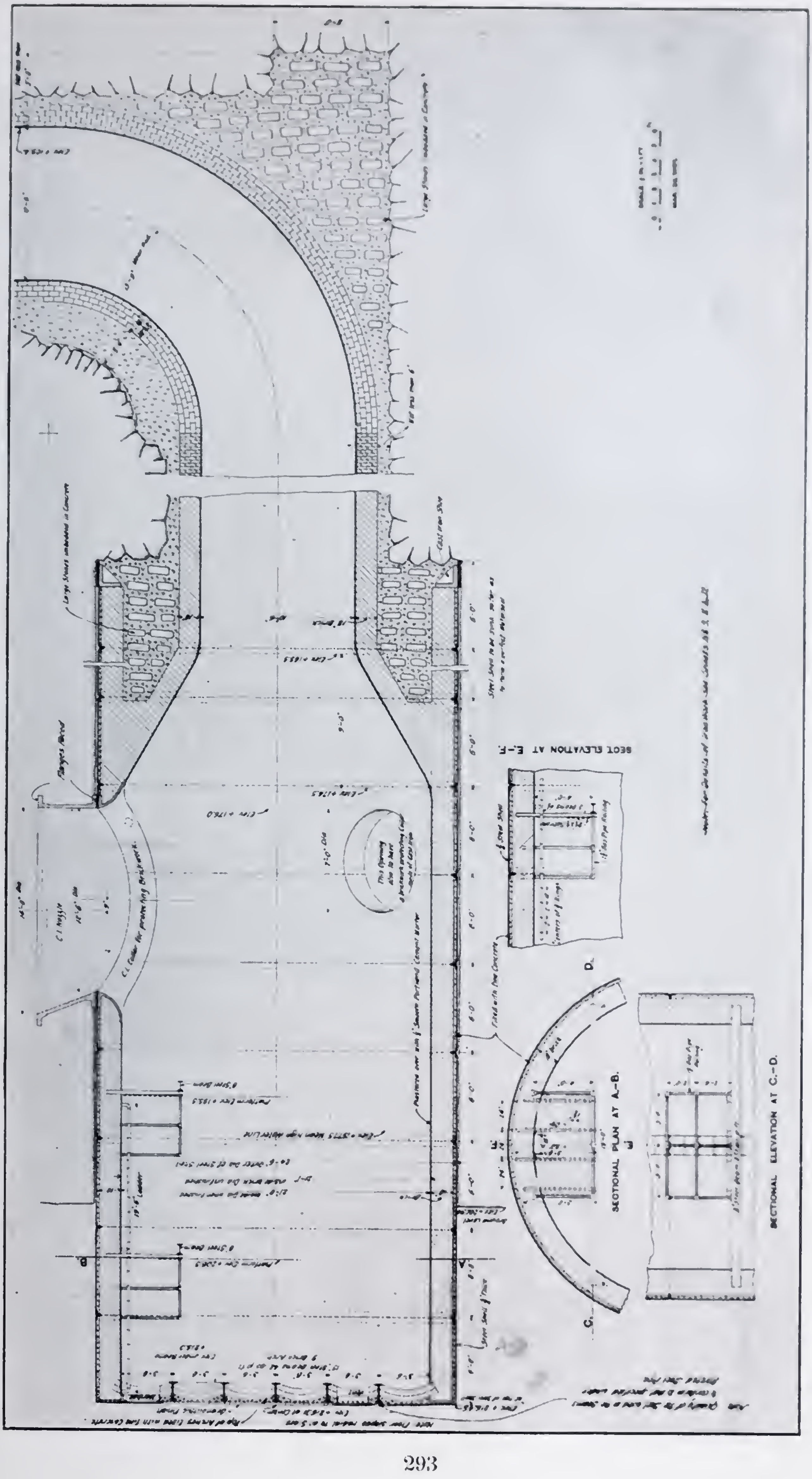

FIG. 20.—TORRESDALE CONDUIT—SHAFT No. 11.

Point. The conduit is uniformly 10 feet 6 inches diameter from shaft No. 1 to shaft No. 11. The total length of conduit, including end shafts to elevation 215.46 T. D., is 14,035 linear feet.

Each shaft is joined to the tunnel by a concrete 90-degree bend, of the same internal diameter as the shaft—viz., 10 feet 6 inches. The bends are turned on a radius, center line of 15 feet 9 inches. The inner surfaces have a granolithic finish 1 inch thick.

The only deep rock operations from which information could be derived upon the probable character of the materials to be encountered in driving the headings for the northerly end of the Torresdale conduit are found near the House of Correction and north of Pennypack Creek. Here the rock excavated in the deep quarry is very hard, with few seams or fissures flowing water, and the typical sections showing excavation for the conduit were partially based on this information.

Experience has shown that the character of the rock in this quarry is not maintained for the whole length of the conduit, and that a great change in the hardness and stability of the material takes place in going from the north to the south end of the work. The treacherous material, however, is not continuous, but occurs in reaches of the work, sometimes being abreast of and sometimes crossing the line of the tunnel.

The diamond drill borings which preceded the preparation of the detail plan indicated the varying nature of the work, but the rapidity with which some of the material would deteriorate upon contact with the air in the tunnel was not fully suspected.

The conduit is constructed with nine working and two permanent (end) shafts. All shafts are opened to full depth and lined to the solid rock, and over 12,500 linear feet of heading has been driven. The working as well as the permanent shafts are constructed with steel shells sunk into hard rock and sealed, the interior being lined with an 18-inch ring of hard-burned stretcher brick laid in cement mortar. The sinking and lining of the steel shells for the end shafts was much more carefully executed than it was for the working shafts, because the latter in due time will be closed with brick arches sprung from abutments cut in the rock at the sides of the shaft above the arch of the conduit, above which will be constructed in each shaft one or two relieving arches to take a part of the weight of the backfill of shaft off the arch of the conduit. From the arch of the conduit to ground-level the working shafts will be solidly backfilled when the conduit has been completed.

Figure 21 shows tunnel excavation in solid rock, where the material was sound and required no timbering. About 86 per cent. of the entire excavation is in material which requires no support; but in the north end of the conduit, while the rock is very satisfactory for tunnel work, the flow of water into the workings has been a source of annoyance. The reach of the conduit between shafts Nos. 4 and 7 presents excellent material for shaft and tunnel excavation, and the flow of water has not imposed any serious hardships on the contractors.

Figure 22 shows some of the work in treacherous ground, in the

FIG. 21.—TORRESDALE CONDUIT—SOUTH HEADING, SHAFT NO. 10.

north heading of shaft No. 8, and indicates the character of the falls following the blasts. The inscribed lines show the outer surface of the brick invert and arch of standard sections, but in all localities where the material over the arch is liable to move after the timber supports have been drawn, the thickness of the arch is being increased by one or two rings of brickwork.

For several hundred feet in the north heading of shaft No. 9, opposite the Disston Saw Works, the collar beams and posts supporting the roof abut against each other to prevent dangerous falls and possible injury to valuable surface structures.

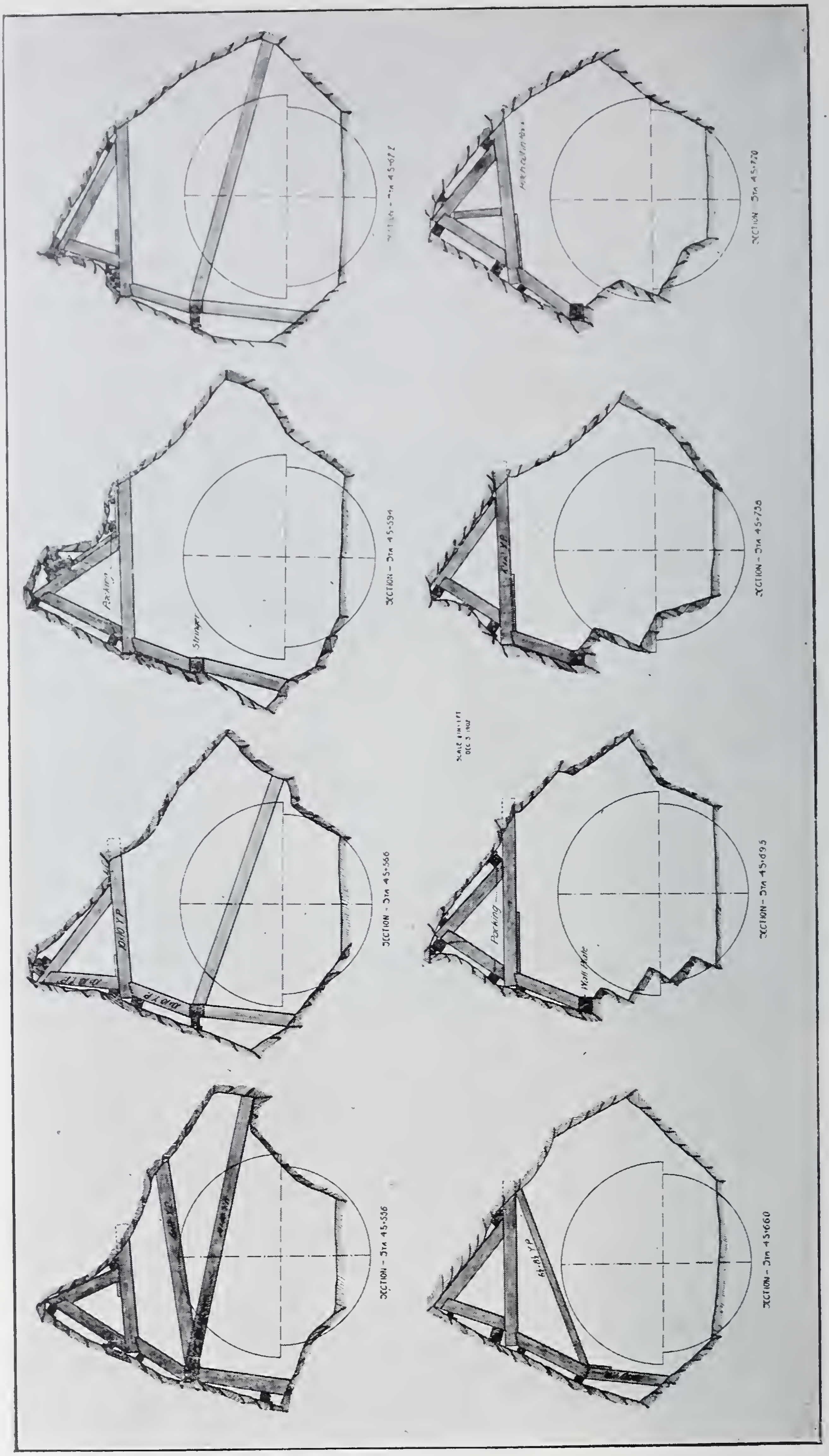

Fig. 22.—Torresdale Conduit—Timber Sets, North Heading, Shaft No. 8.

The conduit is graded upward at the rate of 9 inches per 1000 feet from the influent shaft No. 1 to the effluent shaft No. 11, to prevent the tunnel becoming air-bound (Fig. 18). Air which may be carried down shaft No. 1 will either be carried into the tunnel or rise through the water in the shaft. Such air as may be carried into the tunnel will flow with the water and be vented at shaft No. 11, the upward inclination of the tunnel from the influent to the effluent shaft preventing the accumulation of air, which might be a cause of interference with the operation of a horizontal tunnel. Should there ever be any indications of air sticking, as it were, in the conduit, it is believed that it can readily be removed by increasing the speed of the pumping machinery at Lardner's Point, lowering the level of water temporarily in the pump wells, and creating an increased velocity of flow through the conduit. The conditions under which the water is conducted to the influent shaft, and the upward gradient of the tunnel from the influent to the effluent shafts, are thought to be effectual safeguards against the introduction of any considerable quantity of air into the conduit, or of any impairment of its capacity by an accumulation of air at any point along the roof.

The capacity of the conduit was originally calculated as 300,000,000 gallons per day, with a loss of head 8.6 feet between the level of water in shaft No. 1 at Torresdale and shaft No. 11 at Lardner's Point, but of course the carrying capacity will largely depend upon the accuracy with which the lining is constructed and the evenness and smoothness of the plaster finish on the interior face of the brickwork. Late investigations of the hydraulic conditions of the conduit suggest a capacity of 320,000,000 gallons per day with such lining as the plans require, and with exceptionally excellent work on the part of the bricklayers, engineers, and inspectors, the capacity may reach 340,000,000 gallons per day, with the loss of head mentioned above.

The pump wells and pumping engines will admit of lowering the level at Lardner's Point considerably more than 8.6 feet, and it is not doubted that in this way the conduit can be made to carry 350,000,000 gallons daily from the Torresdale filters to the Lardner's Point pumping station. Such capacity will not be required for many years,—certainly fifty years or more,—and it can be safely assumed that this single conduit will not be overtaxed during that length of time.

Lardner's Point Pumping Station.

The Lardner's Point pumping station will consist of engine- and boiler-house No. 2 (now under construction as contract No. 29), engine- and boiler-house No. 3, of same dimensions, to be constructed immediately north of engine-house No. 2, and the present Frankford pumping station, known as engine- and boiler-house No. 1.

Each of the new engine-houses, of which the plan of engine- and boiler-house No. 2 is shown on figure 23, will contain six 20,000,000-gallon (daily) pumping engines, and each of the new boiler-houses will contain six batteries of internally fired marine boilers of 800 horse-power each. The first set of three 20,000,000-gallon (daily) pumping engines, for engine-house No. 2, are now being built by the Holly Manufacturing Company, of Lockport, N. Y., and will be completed, so far as the work in the shops can be done, before the engine-house will be ready to receive them.

The engines are of vertical crank and fly-wheel triple expansion type, with a single-acting water plunger and duplex suction and discharge water chambers. Each water chamber is provided with independent removable cast-steel valve-decks. The capacity is based on twenty revolutions per minute, and the contract duty based on the coal actually burned in the boilers is 130,000,000 foot-pounds per 100 pounds of coal. The combined rating of the engines in the two new houses and in the present Frankford station is over 13,000 horse-power.

The system of conduits or aqueducts for the distribution of the filtered water to the pumping station (Fig. 24) embraces two main conduits leading from shaft No. 11, with inverts placed at elevation 176.00 C. D., the larger of which consists partly of a circular riveted steel pipe 14 feet diameter, 28 feet long, joined to the flange of a cast-iron nozzle attached to the steel shell of the shaft, and to a horseshoe section concrete and steel conduit equal in area of waterway to a 14-feet diameter circle. The cast-iron nozzle which connects this conduit to the shell of the shaft is a flange offset reducer 12 feet 6 inches diameter at the shaft, and 14 feet diameter at the joint with the steel pipe. This connection is intended for a daily discharge of 300,000,000 gallons when required in the future.

The smaller conduit, 7 feet diameter, consists of a riveted steel pipe 28 feet long, which, at one end, is connected with the shell of the shaft through a cast-iron nozzle of same diameter, and at the other end to a horseshoe-shape concrete and steel conduit equal in

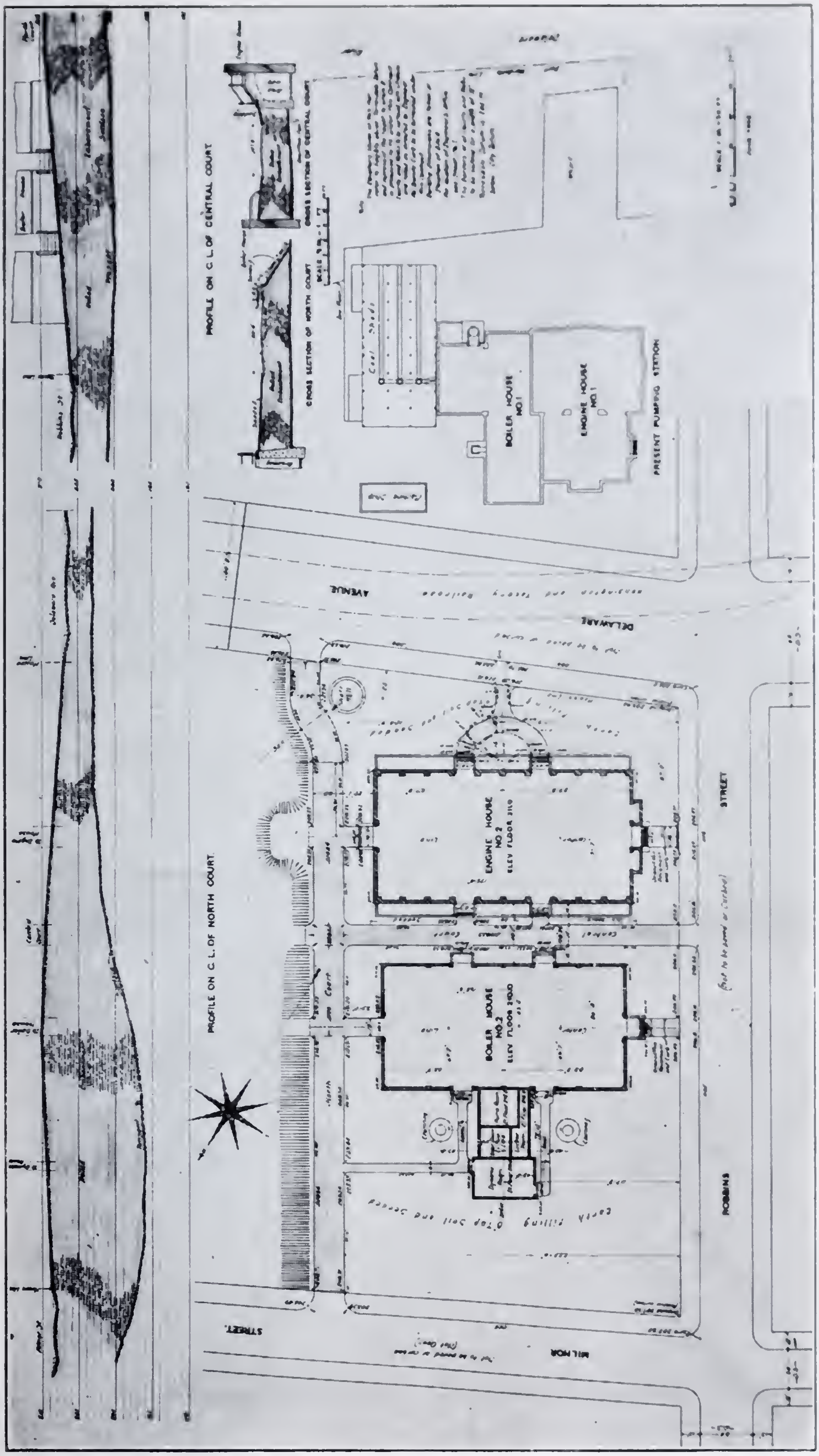

FIG. 23.—LARDNER'S POINT PUMPING STATION—PLAN OF BUILDINGS AND COURTS.

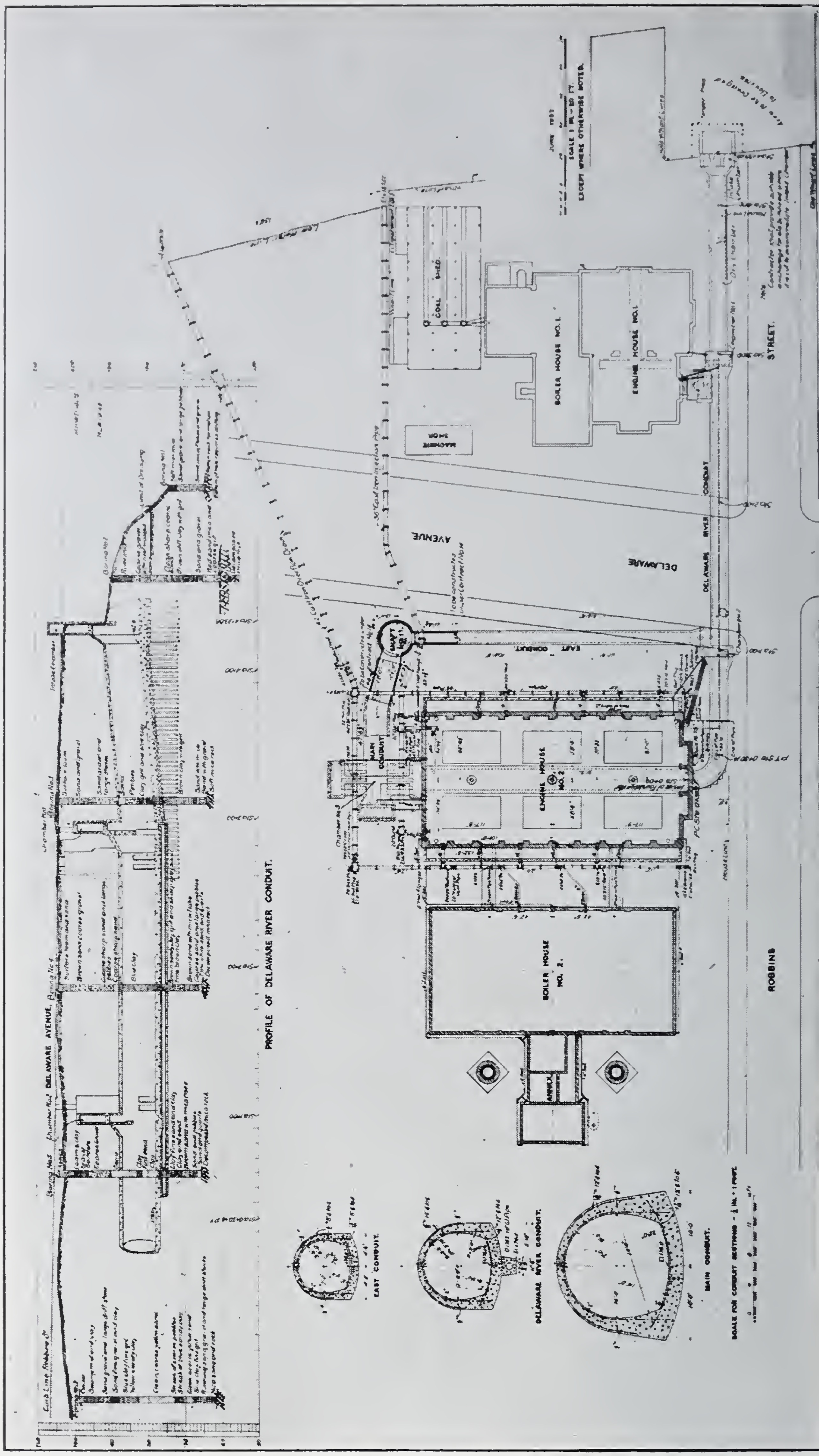

Fig. 24.—Lardner's Point Pumping Station—Conduits and Piping.

area to a circle 7 feet diameter. This conduit is intended to supply water to the present pumping station termed engine-house No. 1.

The pump well of engine house No. 2, and the smaller conduit from shaft No. 11, connect into another concrete and steel conduit of horse-shoe section equal in area to a circle 9 feet diameter, which is extended eastward on Robbins Street to a gate chamber in the Delaware River. The latter conduit, known in the plans as the Delaware River connection, is provided with a double gate chamber to admit of taking water direct from the river into the pump well of engine-house No. 2 and to the engines in engine-house No. 1, until such time as the water is brought from the Torresdale filters, after which the sluice gates in both chambers will be closed and the section of conduit between them becomes a so-called dry chamber, from which water leaking through the gates from the river, or from the filtered water portion of the conduit, will be pumped into the sewers from a well provided in engine-house No. 2. Attention to the level of water leaking into the dry chamber will prevent any pollution of the filtered water in the conduits and pump wells by leakage through the gates at the river end of the Delaware River connection.

The gate chamber, which is supplied with water through the 14 feet conduit, is built with three sets of sluice gates to control the flow of water to the pump well of engine-houses Nos. 2 and 3, and to a future engine-house which will be located at the intersection of Milnor and Levick Streets, west of the proposed location for engine- and boiler-houses No. 3.

I regret that I am unable to present a view of the elevations and finished appearance of the new pumping stations, which it is thought will compare favorably with any modern pumping houses built by other cities, and in view of their great size and very elaborate sub-structures will not be unusually expensive structures for the purpose.

Lardner's Point Pipe Distribution System.

From the pumping stations at Lardner's Point the filtered water will serve the Queen Lane and East Park distribution districts through a system of 60-inch and 48-inch cast-iron mains (Fig. 25).

Each of the four sets of 20,000,000-gallon pumping engines will discharge their water through a short line of 48-inch cast-iron pipe into four lines of 60-inch pipe in Robbins Street, uniting with these pipes in gate chamber No. 1.

The four lines of 60-inch pipe will be laid in Robbins Street from

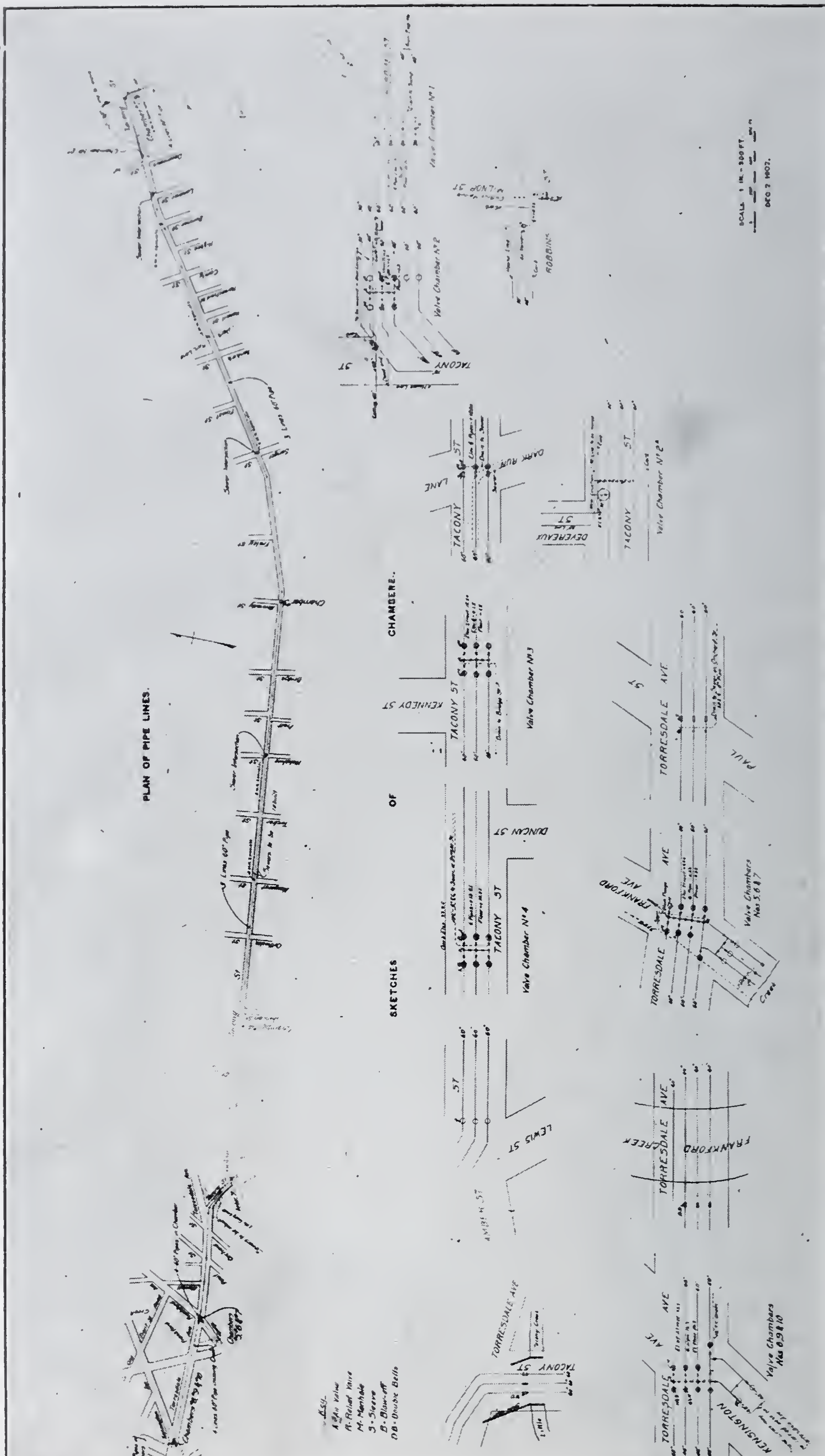

Fig. 25.—Lardner's Point Pipe Distribution System—General Plan.

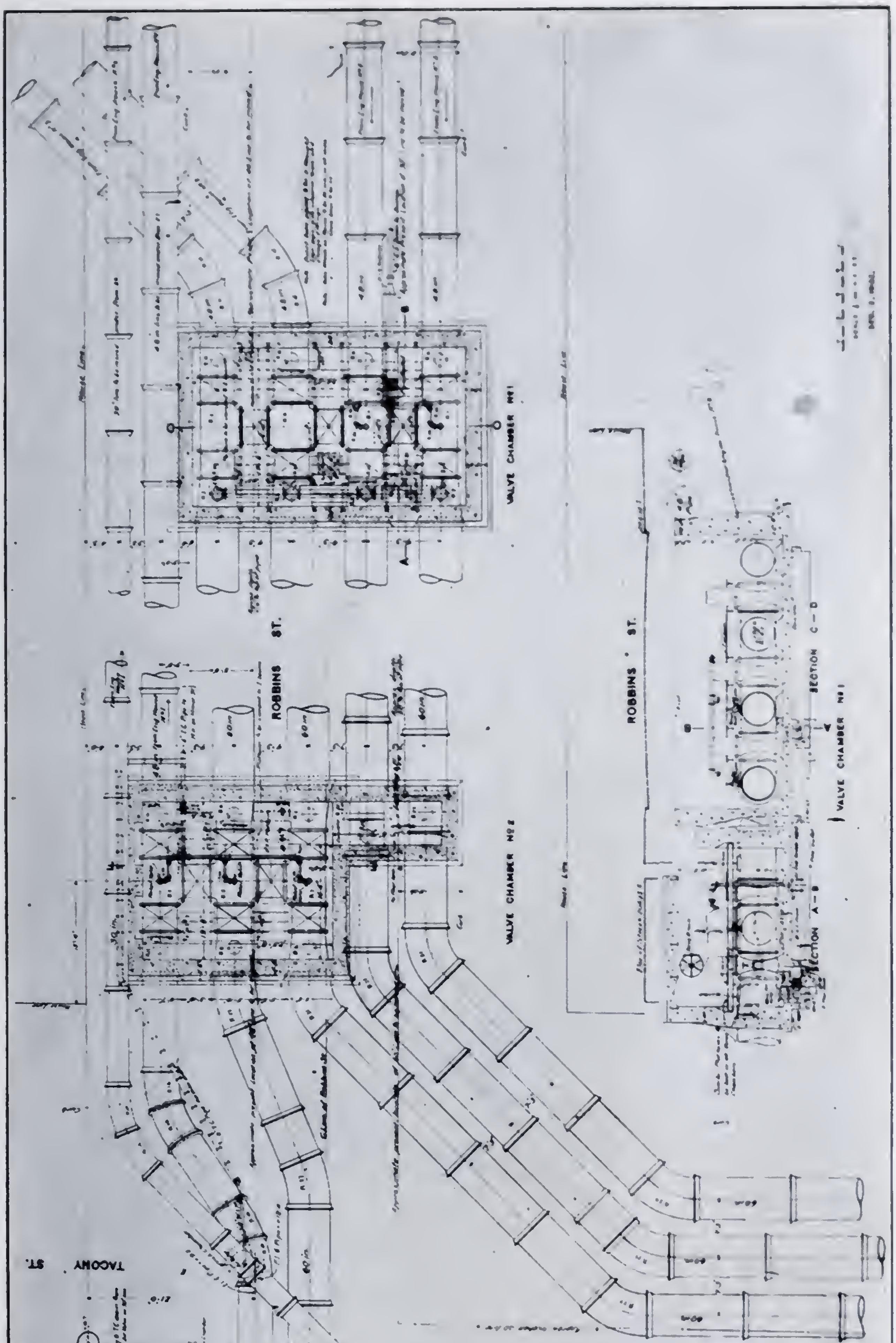

FIG. 26.—LARDNER'S POINT PIPE DISTRIBUTION SYSTEM—VALVE CHAMBERS NOS. 1 AND 2.

gate chamber No. 1, near Milnor Street (Fig. 26), to Tacony Street or Old State Road; at this point the north line of pipe will be temporarily stopped to be continued in the future on Robbins Street to Torresdale Avenue, thence on Torresdale Avenue to Kensington Avenue, passing through gate chambers Nos. 5 and 8 (Fig. 27). The other three lines will be laid in Tacony Street from Robbins Street to the intersection with Torresdale Avenue, and thence in Torresdale Avenue to Kensington Avenue, where the four lines of 60-inch pipe will end in gate chamber No. 8.

The three lines of pipe in Tacony Street occupy the roadway nearly from curb to curb, and together with the short length of the fourth line, now to be laid under contract No. 28, comprises nearly 45,000 linear feet of 60-inch pipe. From the terminus of the four lines of 60-inch pipe, nine lines of 48-inch pipe will lead into the Queen Lane and East Park districts, to complete the main feeders for the supply of filtered water from the Lardner's Point pumping station.

At the two terminal points, and at distances apart of about 4000 feet, masonry valve chambers will be built (Figs. 26 and 27), in which will be placed the special castings and stop-valves to control the flow of water in the event of injury to either line of pipe, and avoid the temporary loss of the use of more than 4000 feet of one line of pipe while repairs are being made. To prevent, as far as possible, injury to these large pipes, each line is provided with a pop relief valve in each gate chamber, set to blow at 125 pounds, in addition to relief valves on the discharge pipes of the pumping engines at Lardner's Point, set to blow at 120 pounds per square inch.

Figure 27 shows the location of the gate chambers, earlier mentioned, along the lines of 60-inch distribution mains on Robbins and Tacony Streets and Torresdale Avenue. The stop-valves and all special castings built in the chambers are flanged work. Each line of 60-inch pipe enters and leaves the chamber through a 60-inch to 48-inch hub and flange reducer. All valves are 48 inches diameter, partly to reduce the cost of the work and partly to limit the depth of excavation at the chambers. A 48-inch stop-valve is a well-exploited detail of waterworks construction, involves no risk when properly proportioned for the pressure under which it will work, is much less expensive, and requires less depth of chamber than a 60-inch valve. A careful investigation of the probable extra loss of head by the use of 48-inch valves compared with 60-inch valves indicates less than 0.30 foot for the entire number in each line of pipe. The cost of over-

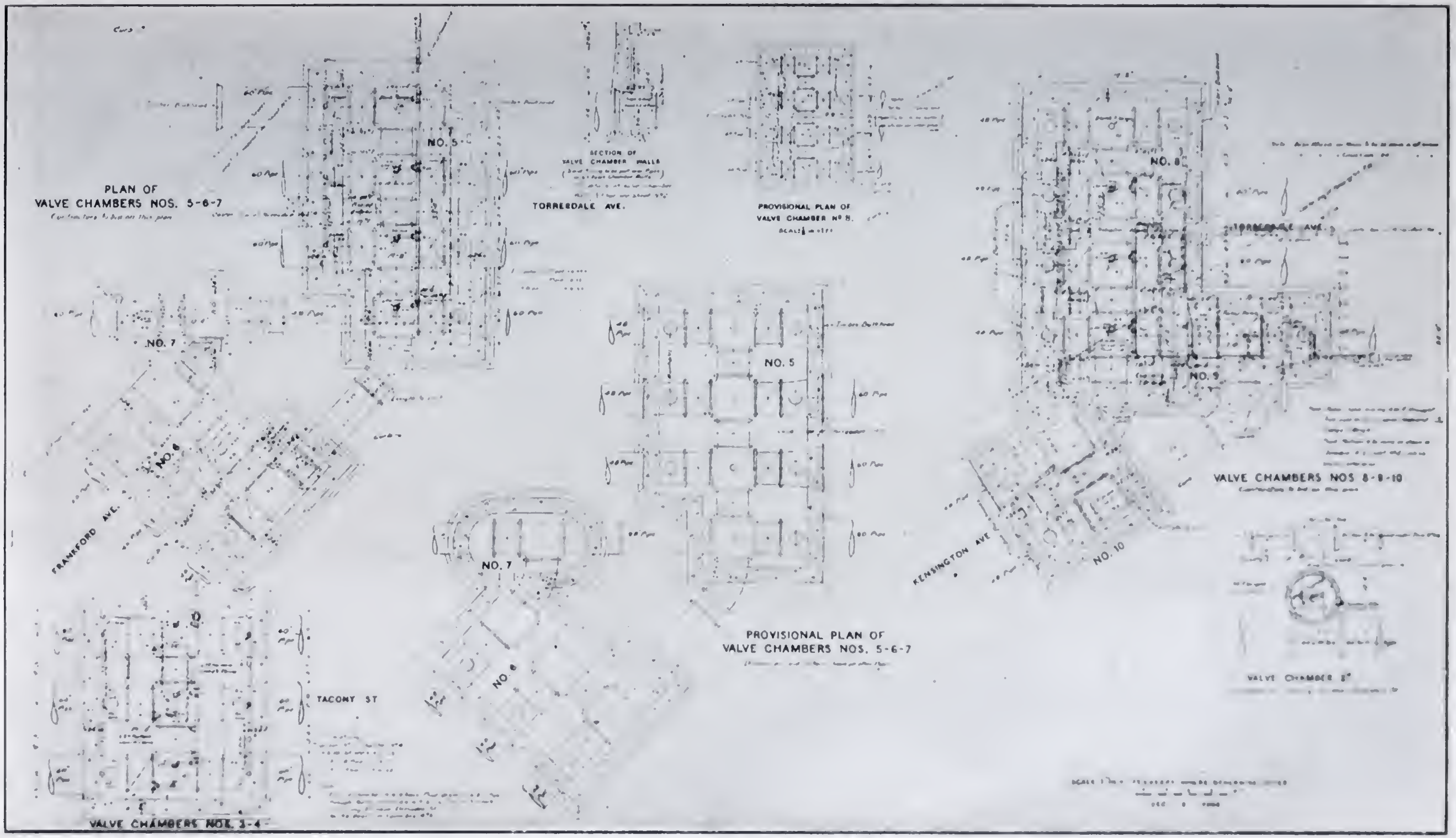

Fig. 27.—Lardner's Point Pipe Distribution System—Valve Chambers Nos. 3–4 and 5–6–7, and 8–9–10.

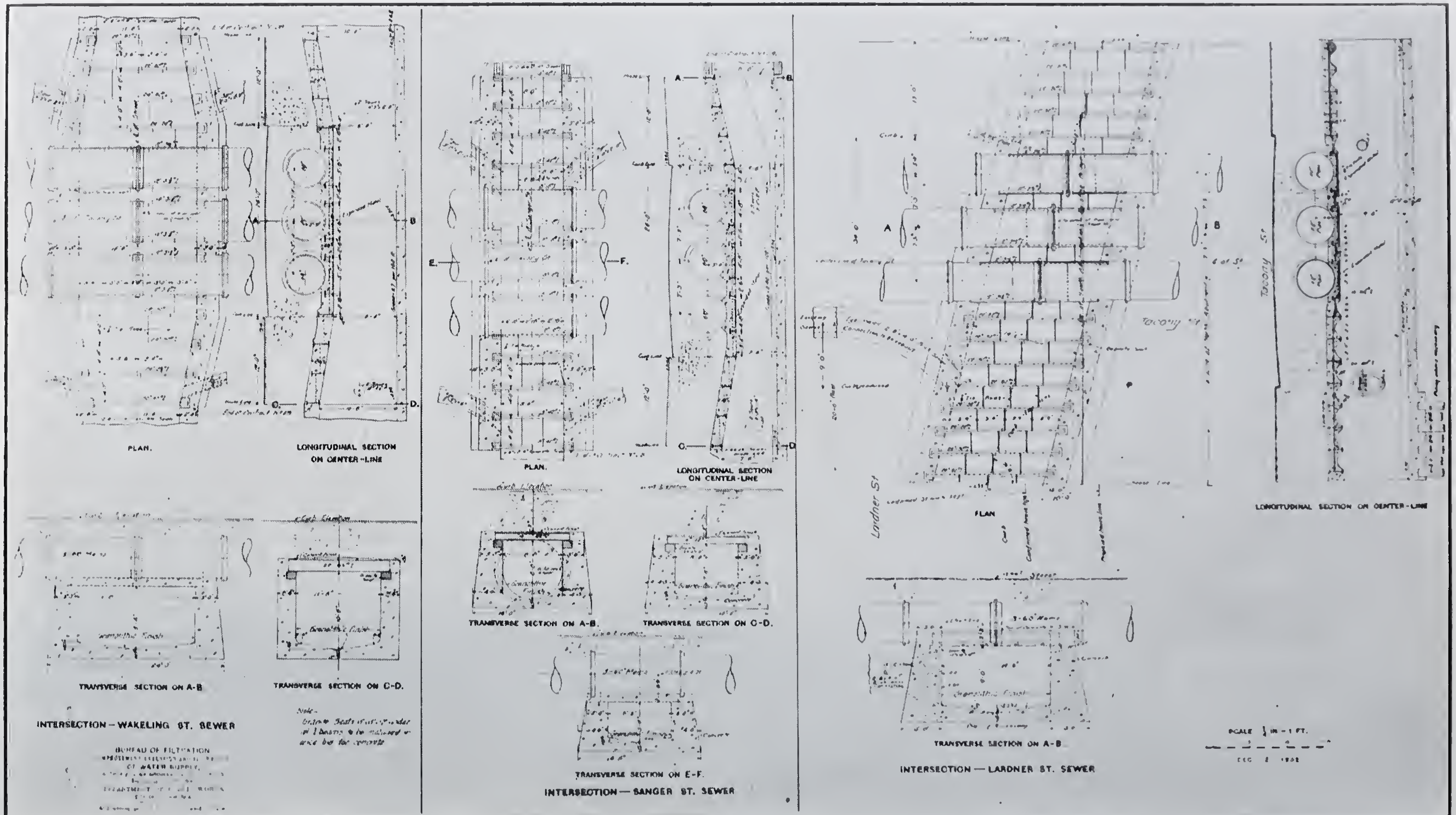

Fig. 28.—Lardner's Point Pipe Distribution System—Sewer Intersections.

coming this additional loss of head by the pumping machinery at Lardner's Point was very much less than the annual fixed charges on the additional cost of the work of construction if 60-inch instead of 48-inch stop-valves had been used.

Figure 28 shows three large sewer intersections at Lardner, Sanger, and Frankford Streets, where the 60-inch pipes are carried over concrete chambers with inverts at the same grade and elevation as the sewers, but with the crowns or roofs depressed to admit of sufficient cover for the pipes above. In laying the pipes the principle held that, however remote the probability of accident, ample provision should be made for certain, convenient and quick repairs, and shallow trenches and placing of pipes above important intersected sewers were early decided upon.

The sewer chambers have roofs in all cases below the elevation of mean high water in the Delaware River, but the channels are of such sectional area as to provide a velocity of flow not less than that of the connected sewer. At Lardner and Frankford Streets the chambers are of such width as to require the use of two lengths of flange pipe to span the opening. In these cases the pipes are treated as beams to carry part of the street load, and transmit it to the side walls of the chambers. The roofs of the chambers consist of concrete arches supported on the flanges of steel beams.

Plan of Oak Lane Reservoir.

Figure 29 shows in plan the Oak Lane reservoir, which is intended solely for compensation for the varying hourly rates of water consumption, and to limit the head on the Lardner's Point pumping machinery. The flow line is at elevation 210.00 C. D., with a water depth of 20 feet 6 inches. In the construction of this basin provision has been made for covering it, if it shall be found that exposure of the filtered water in such volume (70,000,000 gallons) to the light and air is attended with any ill effects. Such experience as we have had with filtered Schuylkill River water does not indicate appreciable deterioration through considerable lengths of time by exposure in clear bottles to the light, but this experience may not apply with equal force to the filtered Delaware River water which will be pumped to the Oak Lane reservoir; and if it is found desirable that this basin should be covered, the plans have been worked out to provide for a covering by the addition of the necessary piers, and a steel and timber or concrete vaulted arch roof. The preponderance of available data seems to indicate

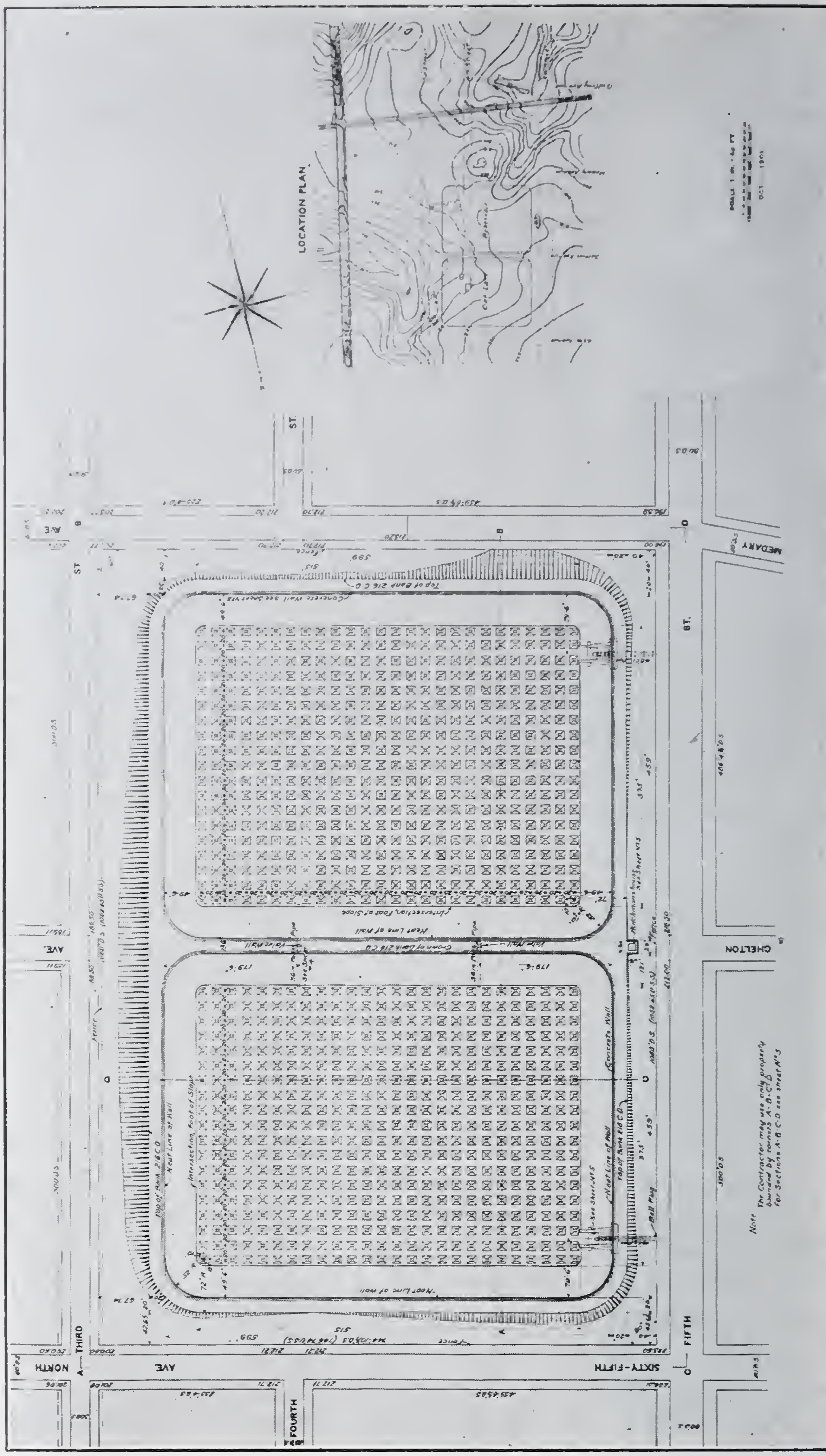

FIG. 29.—OAK LANE RESERVOIR—GENERAL PLAN.

that a covering is not essential, and in its early history the reservoir will be worked as an open basin.

The Lawrence (Mass.) reservoir, receiving filtered water from the Merrimac River, contains about thirteen days' storage and is uncovered; no ill effects to the filtered water by the exposure, so far as I am aware, have been reported from Lawrence. Upon the other hand, the Quincy (Ill.) reservoir receiving filtered Mississippi River water, holding about the same number of days' supply, required covering to prevent an objectionable growth of algæ in the water. There is, however, this difference in the two instances cited: at Lawrence the water is filtered through plain sand filters, without the aid of alum or other chemicals, while at Quincy rapid mechanical filters with a coagulant containing alum or iron as the astringent are used. How much, if at all, the use of a chemical in the filtration of water at Quincy may have caused deterioration in the water when exposed to the light and air for twelve to thirteen days in an uncovered reservoir, I do not know; but it is possible that the dissolved chemical in the filtered water might have stimulated the growth of certain species of algæ.

Capacity of Works.

The capacity of the works, as planned and generally under contract, may be recapitulated as follows:

	Gallons per Day.	
Torresdale Filters.		
Fifty-five filters, Torresdale contingent and preliminary filters,	210,000,000	
Ten filters, Queen Lane contingent and preliminary filters,	38,000,000	
Total of Torresdale,	248,000,000	
Belmont Filters.		
Eighteen filters and preliminary filters,	67,000,000	
Roxborough Filters.		
Lower Roxborough, five filters and preliminary filters,	12,000,000	
Upper Roxborough, eight filters and subsided water,	20,000,000	
Total,		347,000,000

Upon the assumption that upon the completion of the works the city may adopt water meters, or some other remedy for the unnecessary waste, and that an average allowance of 150 gallons per capita per

diem will meet all reasonable requirements of consumption, the capacity of the works as planned and now under contract (excepting Queen Lane contingent of ten filters at Torresdale) will be as follows:

Torresdale capacity will serve a population of........	1,680,000
Belmont capacity will serve a population of..........	420,000
Roxborough capacity will serve a population of......	213,300
Total, ...	3,313,300

It is estimated that the population of the city in 1950 will not exceed 3,500,000, and upon this basis the present works of filtration are projected from forty to fifty years in the future.

Population Supplied and Consumption of Water in Nineteen of the Largest American Cities.

Cities.	Population Supplied.	Consumption. Gallons Daily.	Consumption. Gallons per Capita.
Philadelphia, ...	1,254,000	287,188,000	229
New York,..............	2,049,000	245,700,000	120
Chicago, ...	1,698,600	323,000,000	190
Brooklyn, ...	1,110,000	95,900,000	86
Boston, ...	560,900	80,000,000	143
Cleveland, ...	420,000	66,900,000	159
Buffalo, ...	400.000	92,365,000	233
St. Louis,...............	400,000	63,530,000	159
San Francisco,...........	342,800	25,000,000	73
Cincinnati, ...	325,900	39,600,000	121
Detroit, ...	306,055	44,800,000	146
Milwaukee, ...	300,000	24,000,000	80
New Orleans, ...	287,104	13,820,000	48
Pittsburg, ...	234,000	54,000,000	231
Minneapolis, ...	202,718	18,813,000	93
Providence, ...	187,300	10,130,000	54
Indianapolis, ...	169,164	13,400,000	79
Allegheny, ...	130,000	39,000,000	300
Denver, ...	100,000	30,000,000	300

The proposition to so restrict the needless wastes and reduce the per capita daily consumption of water possibly to 150 gallons is sustained by reference to certain cities in the following table of water consumption in nineteen of the principal cities of the country for the year 1902. Cincinnati, Cleveland, Milwaukee, Providence, and St. Louis are thus all manufacturing cities, in which, excepting Milwaukee and Providence, meters are not generally used, and the consumption of water is regarded as excessive, and the same complaint of water

waste with the two exceptions noted is made there as it is in New York, Boston, and other cities not generally metered.

Denver is supplied partly from gravity sources in the South Platte Valley, or by water-power pumping from the Platte River, a small portion of the water from Cherry Creek being also pumped. At Pittsburg several years ago I was informed by the superintendent of the waterworks that in his opinion the large apparent consumption was due to leaks in the street mains, and that his experience in making connections and repairs revealed a considerable loss from bad joints.

Assuming that the general introduction of water such as is now coming from the Lower Roxborough filters will have an effect to reduce by 80 per cent. the typhoid fever rates, the direct money value to the city of this reduction is estimated at $2,284,000 per year, an amount which, capitalized at 5.5 per cent., the fixed charges on the bonds issued for construction of the works, for thirty years, equals $33,195,656, which I consider as the present value of the general filtration of the public water-supply.

The following total quantities apply to the contracts executed to date:

Excavation,	2,371,000	cu. yds.	
Rolled earth fill,	259,000	"	
Rolled embankment,	595,000	"	
Puddle,	228,000	"	
Concrete masonry,	315,500	"	
Rubble masonry,	2,200	"	*
Brick masonry,	23,000	"	†
Cast-iron water-pipe,	72,000	tons.	
Special castings,	2,850	"	
Structural steel,	3,362,000	pounds.	‡
Cast-iron fixtures,	1,163,000	"	‡
Wrought iron,	101,000	"	
Stop-valves,	1,259		
Check-valves,	130		
Rotary valves,	18		
Regulator houses,	49		
Gate houses,	9		
Valve Chambers,	15		
Administration buildings,	3		
High-lift pumping stations,	2		
Low-lift pumping stations,	3		

* Does not include inverts of sewers, contracts No. 25 and No. 29.

† Does not include regulator or gate houses, sewers, and manholes.

‡ Does not include manhole frames and covers, fasteners in vaulting, sewer inlets, filter ventilators, nor appurtenances to piping.

Enough has been shown to-night to indicate in a vague manner the magnitude of these works. Many of the details are worthy of much more time for their proper presentation than I have taken to briefly sketch out the whole system. Many interesting problems have arisen in developing the plans and constructing the work which I sincerely hope have been properly worked out. The amount and varying character of the detail are such that nothing short of a volume such as Mr. Edward Wegman, C.E., has so admirably written of the old and new Croton aqueducts can properly present it to engineers interested in works of its character, and I cannot hope that my brief talk this evening, together with the lantern slides shown, can do more than give you an inkling of this great work.

The readjustment of sources of supply, costing as it does a large sum of money, aside from the cost of the works of filtration at Torresdale, possesses several points of vital interest. At the present time there is pumped from the Schuylkill River for the city supply a daily average of 283,429,000 gallons, while the Delaware River furnishes 30,160,000 gallons, or a total, as shown by the report of the Bureau of Water for 1902, of 313,589,000 gallons. The Schuylkill River thus furnishes at the present time over 90 per cent. of the water consumed. By the new plans based on the present daily consumption the Schuylkill River will furnish about 20 per cent. of the water and the Delaware River will supply the remainder. In view of the large substitution of the Delaware for Schuylkill water, some inquiry is bound to arise as to the relative merits for domestic and other purposes of the two sources of supply.

From a table showing the weekly averages for 1902 of the leading data from the chemical and bacteriological examinations of the two rivers, I quote the following upon the condition of the raw waters:

TURBIDITY IN PARTS PER 1,000,000 BY THE SILICA STANDARD.

Delaware River, average for year,	53
Schuylkill River, average for year,	100
Delaware River, maximum for year,	460
Schuylkill River, maximum for year,	1,100
Delaware River, minimum for year,	9
Schuylkill River, minimum for year,	9

BACTERIA PER CUBIC CENTIMETER.

Delaware River, average for year,	6,405
Schuylkill River, average for year,	14,160
Delaware River, maximum for year,	24,000

Schuylkill River, maximum for year,	86,000
Delaware River, minimum for year,	550
Schuylkill River, minimum for year,	630

COLOR BY THE PLATINUM COBALT STANDARD.

Delaware River, average for year,	0.19
Schuylkill River, average for year,	0.09
Delaware River, maximum for year,	0.40
Schuylkill River, maximum for year,	0.22
Delaware River, minimum for year,	0.10
Schuylkill River, minimum for year,	0.04

HARDNESS, EQUIVALENT TO CARBONATE OF LIME.

Delaware River, average for year,	51.00
Schuylkill River, average for year,	87.00
Delaware River, maximum for year,	94.00
Schuylkill River, maximum for year,	124.00
Delaware River, minimum for year,	26.00
Schuylkill River, minimum for year,	44.00

It will be noticed from the data quoted that in all respects other than color the Delaware River furnishes the better natural water. Considering filtration of the two waters, the data quoted and the experimental results at the testing stations indicate the Delaware as the most favorable water to work with. Considering the color, the filtered Delaware water, when viewed in a clear glass beaker alone, would not to an unpractised observer suggest color, but when compared with filtered Schuylkill water the darker appearance of the water is then evident.

Plain sand filtration cannot be relied upon to remove or largely reduce color where, as in the Delaware River water, it is due to vegetable stain. But so far as I am aware the dissolved matter which imparts color to either the Schuylkill or Delaware water is not inimical to health.

The increased color found in the water of the Delaware River is probably due to the swamp water from the Rancocas and other creeks flowing into the river from New Jersey.

Omitting this single condition of color, which I do not know to be objectionable from a sanitary standpoint, I think it is fair to assume the Delaware River water as the better of the two sources.

COMPARISON OF EXPERTS' ESTIMATES AND ACTUAL COST.

With reference to the cost of the work: The report of the experts aggregates a gross outlay of $14,569,989, or, in round numbers, say

$14,570,000, based upon works to supply 200,000,000 gallons daily of filtered water. The general plan of the experts, however, as I have since been informed by members of the commission, contemplated some improvements that were not incorporated in their summary of cost. For example, a basin which would have had the same function as the Oak Lane reservoir (contract No. 27) now under construction is known in the experts' report as the Olney Avenue reservoir. This reservoir, it was thought, would be required for compensation and limited storage in the event of gravity supplies being brought into the city. Upon further study of the general subject it appeared to be advisable to incorporate in the Torresdale plans such a reservoir at an elevation higher than the Wentz Farm reservoir to aid in the distribution of water from the Torresdale filters. The amount estimated for the Olney Avenue reservoir was $1,000,000 (page 81 of the experts' report).

In developing the Belmont scheme it was thought by the experts that the additional reservoir at George's Hill, planned by the Bureau of Water, at an estimated cost of $500,000, which, pro rated upon the cost of the settling basin for the Belmont works (contract No. 16), would have cost to construct about $790,000, would have been made a part of the plans as proposed by them. That is to say, as I understand, the experts believed that the George's Hill reservoir would be increased in capacity by 85,000,000 gallons, and that it was desirable to pump first to subsiding basins at George's Hill and then pump the water again to the filters at Belmont Avenue and Ford Road. The value of this reservoir is essentially a part of the cost of the improvements proposed by the experts, but was not incorporated in their summary.

The filters at the Torresdale station were connected with the distribution system by one line of 48-inch pipe, and one line of 30-inch pipe, extending southward on State Road as far as Robbins Street, where they intersected the present 48-inch and 30-inch rising mains from the Frankford pumping station. The capacity of these pipes, with the same loss of head as is allowed for in the Torresdale conduit, is about 30,000,000 gallons per day of twenty-four hours, or less than the capacity of the filters planned for the Torresdale station. By substituting the Torresdale conduit for the cast-iron mains mentioned in the experts' report we have provided a daily capacity of over 300,000,000 gallons with the same loss of head between the Torresdale filters and Lardner's Point as that allowed for the cast-iron mains

for a carrying capacity of 30,000,000 gallons per day, and making provision for the ultimate capacity of the Torresdale station as estimated for by the experts. This detail involves an increased cost of $1,350,000.

Another feature of the experts' report to which your attention can properly be called is that the 200,000,000 gallons daily consumption was based upon the general metering of all water services, and no allowance is made in the summary for the cost of installing the meters. The adoption of a meter system was clearly regarded by them as an essential part of the improvement. I am not calling attention to this with a view to criticizing the report of the experts, which, after three years' study, and considering the limited time at their disposal, I believe is in all respects admirable, but to show why the actual cost of the work constructed is bound to be greater than the figures written in their report.

Another condition which must be considered is the difference between the cost of labor and materials in 1899 and during the years 1901, 1902, and at present. All materials for waterworks constructions and labor command higher prices to-day, and with reference to common labor and some skilled labor the amount of work performed at the higher prices is actually less than that which was performed at the prices prevailing in 1899; this is bound to have a marked influence upon the figures made by the contractors who assume the responsibility for constructing the work, and is a contingency which it would be unfair to assume that the experts provided for.

DISCUSSION.

The President.—The paper is open for discussion, gentlemen. I am sure that Mr. Hill will be glad to answer any questions that suggest themselves to you.

James Christie.—Mr. President, while offering a resolution of thanks to Mr. Hill for the paper he has presented to us this evening, I wish to preface it by expressing the satisfaction that Philadelphians should feel, that after so many years of agitation, extending over the last quarter of a century; after an extended discussion of all sorts of schemes for the solution of the question of pure water, we have at length nearing completion a comprehensive system which utilizes the impure water passing by the city and will distribute it to us in a satisfactory condition.

I think it is now generally recognized that no surface water anywhere is in the proper condition for drinking without passing through some process of purification. So no matter where we would have gone for water-supply, if we

had taken surface water, the necessity for filtration would be almost as great as for that we have at hand. In addition to such diseases as typhoid and cholera, which affect the alimentary system of the human adult, it is known that infantile mortality is largely augmented by the presence of injurious organisms in milk and water. Wasting diseases resulting in inanition and atrophy are responsible for much of the mortality in young children. The good results that have followed from proper systems of sterilization for milk and water have demonstrated this. Pure water supplied to infants will tend to reduce the summer ailments in children, and the loss of a promising infant is certainly a greater calamity than the removal of a bad man.

Those of us who have found it convenient to frequently visit the filtration plants described by Mr. Hill realize the magnitude and immensity of the work and the great skill that has been displayed by the engineers and contractors in its execution. The work has been admirably handled and will rank with the best of its character anywhere.

We hope, Mr. President, that at some future evening some member of Mr. Hill's staff may be able to present to us a description of the methods used by the contractors in prosecuting this work. I move a vote of thanks to Mr. Hill for the trouble he has taken in the presentation of the subject before us this evening. (The motion was put and carried unanimously.)

The President.—The meeting is open to further discussion.

Samuel S. Sadtler.—May I ask, Mr. Hill, how nearly the bacteria are removed from the filtered water?

Mr. Hill.—The last two weekly reports from the Lower Roxborough filters show an average bacterial content of the effluent water of all the filters for the week ending last Saturday, February 14, 1903, as less than fifty colonies of bacteria per cubic centimeter of water, ranging from thirty-nine to sixty-five colonies of bacteria per cubic centimeter of water. For the week previous to that the average bacterial content was about sixty colonies per cubic centimeter of water. With the exception of about four weeks during the winter, when the water was very bad and wholly unprepared by sedimentation or preliminary filtration before going to the filters, the average bacterial content of the filter effluents rarely exceeded thirty colonies per cubic centimeter of water. Some of the filters have delivered the water with as few as three colonies per cubic centimeter of water—almost sterile water; but until the preliminary filters have been completed to prepare the water for the Lower Roxborough filters, the best work of these filters cannot be shown. Our standard of bacteria per cubic centimeter of filtered water is fifty. So long as the bacteria in the filtered water are not in excess of the standard I do not trouble the man who is in charge of the filters. When, however, the numbers exceed the standard, an investigation is made to locate the cause and remedy the increased bacterial content of the filter effluents.

I can confirm Mr. Christie's opinion that there is no surface water anywhere flowing in rivers or lakes that is naturally fit to go to the consumer for dietetic or potable purposes. To-day, if the water were coming from the Blue Mountains, as proposed by Mr. Hering in his report of investigations during the years 1884 and 1885, there is no doubt in my mind that the city would be building, or perhaps have already built, works of filtration. Those familiar with the

works proposed by Sir Alexander Binnie for the supply of water from the Welsh mountains to London understand that the water is to be gathered in impounding reservoirs in Wales and be passed through plain sand filters before it reaches London. I think Mr. Christie is quite correct in the opinion that no water from natural surface sources should be used for dietetic purposes unless it is first filtered.

The President.—I am glad that Mr. Hill and Mr. Christie have called attention to the necessity of the filtration of any domestic water-supply, no matter where gathered, whether from flowing streams or from surface springs. If I am not mistaken, in Germany it is subject to governmental control.

Mr. Hill.—Yes, it is.

The President.—And no municipality or water company, if such exists in Germany, is allowed to furnish the water of flowing streams for domestic uses without filtration.

I have long known the Schuylkill River and its sources of pollution and I am persuaded in my own mind that a domestic supply from this source is not fit for use without filtration. I hold to the same opinion in regard to the supply from the Delaware River. The difference in the supply from the two streams is only relative, the governing factor in the purity of the two sources being that the Delaware, which is more than four times the size of the Schuylkill in drainage area and volume of flow, has the advantage of greater dilution. In other words, the pollution of the Delaware water is not so apparent to the senses as it is in the lower pools of the Schuylkill.

Nevertheless, there are no regularly sewered cities and towns in the Schuylkill watershed. There are, it is true, isolated cases of public sewers, all of them on a comparatively small scale, in towns and villages, not including the city of Reading, which has expended a large sum of money upon a separate sewage system, for the chemical treatment and filtration of the outflow from the first and second sewer districts of the city, which is the only portion of the system as yet completed. On the other hand, the Delaware River flows through a district part of which is thickly populated. Within a distance of sixty miles of Philadelphia there are five large cities and towns, all of which are sewered, the effluent passing directly to the river, without treatment.

It is therefore necessary to filter the supply from both the Delaware and the Schuylkill. It is the only safe plan to pursue, and the only one which will insure a supply of water safe for use for domestic purposes. With the introduction of filtered water in this city, I feel satisfied that the statement just made by Mr. Hill, that the death-rate from typhoid fever will be reduced 80 per cent., will prove to be entirely correct. Indeed, from such an admirably planned and well-executed plant, a greater reduction in the typhoid rate may be looked for. Surely the community is under obligations to the gentlemen who are carrying on this work so assiduously, for it is in many ways a difficult undertaking and one calling for the largest exercise of engineering skill.

I have in my hands a letter received from Mr. John C. Trautwine, Jr., a member of the Club, which opens up a question which I think he would like to have answered. Mr. Trautwine is not able to be with us to-night. He says in part of his letter:

"It is naturally gratifying to find the work now being carried on upon these

lines, the authorities installing filters and advocating the introduction of meters.

"It seems regrettable that waste restriction, which would have reduced the cost of the filters at least one-half, was not installed first.

"Possibly Mr. Hill can indicate why the natural order of procedure has been reversed."

Mr. Hill.—Three years ago, when this work was begun,—that is, the construction features of the work,—it seemed to me that we ought to give serious attention to the matter of water meters, and one of the earliest steps that were taken was to ascertain the probable number of service connections and the cost of installing a general meter system for the city. It was found there would be required about 250,000 meters, of which 92 per cent. represented meters on domestic service pipes; and upon the average cost of $18 per meter, set and connected in the service pipe, the gross cost was found to be $4,500,000. When the matter was talked over with my assistants, as well as with the Mayor, a statement was made that, if we began by metering such water as is in the second bottle (pointing to the unfiltered Schuylkill water in the bottle on the President's table), we would be liable to be strung up to lamp-posts; that the people might be willing to have good water metered, but not such water as that. (Laughter.) The consensus of opinion of the officials was that we should first filter the water and then take up the matter of adjusting meters to the service pipes. I have the promise of Mayor Ashbridge that he will incorporate in his last message to Councils, which will be prepared within a few weeks, a strong paragraph recommending the use of meters as a means of restricting unnecessary and reckless waste of water from the city mains.

While describing the lantern slides, I overlooked a sketch which, with your permission, I would like to describe at this time. (Mr. Hill turned to a large sketch hanging upon the wall and said:) This is a section of a filter, and I wish to say a few words about the construction of the main collector shown in the center of this filter. (Mr. Hill explained the design.) In the Roxborough filters the construction of the main collectors was the cause of an unexpected leakage through the cracks formed between the main collector walls and the floors of the filters. The water passed through these cracks into the puddle, and doubtless to some extent through the puddle. So in the filters at Belmont and at Torresdale we are building a main collector like this (indicating). In this construction of main collector the walls are built of concrete, with openings through the sides for the reception of the lateral collectors. From each side of the main collector 8-inch perforated terra-cotta pipes are run nearly to the side walls of the filters, the aggregate area of perforations in each length being equal to the area of the pipe.

I consider the perforated pipe to be superior to the unperforated pipe, because it is calculated to effect a more nearly uniform rate of percolation through the gravel underdrains and superimposed sand beds for the whole length of the lateral collector. The perforated lateral collectors, as we are using them in the Philadelphia filters, were first proposed by Mr. James P. Kirkwood in the filters planned by him for the city of St. Louis, nearly forty years ago. So far as I am aware, this city is the first to adopt Mr. Kirkwood's suggestion.

The depth of gravel in the underdrains is 16 inches at the center of the filter bay, divided as follows: At the bottom, 6 inches in depth of gravel, varying in

size from 3-inch to 1½-inch diameters; next above, a depth of 4 inches of gravel, varying in size from 1½ to ¾-inch diameters; next above a depth of 3 inches, varying in size from ¾-inch to ¼-inch diameters; next above, a depth of 2 inches of gravel, varying in size from ¼-inch diameter to particles that will be retained on a No. 14 sieve; and finally, at the top of the system of underdrains, a layer of coarse sand 1 inch thick, composed of particles which will pass a No. 14 sieve and be retained on a No. 20 sieve.

The average thickness of the bed of filter sand placed above the gravel underdrains, both in the filters now running at Lower Roxborough and in the filters in which the filtering materials are now being placed at Upper Roxborough, is 36 inches. The construction of the filters is such that the depth or thickness of the sand bed may be varied between wide limits, although the information gained thus far from the practical operation of the filters at Lower Roxborough suggests a maximum depth of sand bed of 40 inches, and a minimum depth, after repeated scraping, of 20 inches.

After a filter has run until the difference between the level of the water over the sand bed and the level of the water in the effluent chamber at the end of the filter approximates 4 or 5 feet, the inflow of water is stopped and the water on the sand bed drawn off through the collectors until the level is 10 or 12 inches below the surface of the sand, after which operation the upper ¾ inch of dirty sand is scraped off, washed, and stored in the court for future use. When a sand bed, by repeated scrapings, has been reduced to a thickness of 20 inches, one more scraping is made and then the previously scraped and washed sand is brought back into the filter and the sand bed restored to its original thickness of 36 inches, more or less.

L. Y. Schermerhorn.—What are the physical characteristics of sand suitable for filtration purposes?

Mr. Hill.—It does not seem to be much affected by the shape of the sand grain, but it is affected by the size. If there is too much of fine material, the bed will be too dense for practical filtration. If there is too much of coarse material, the water goes through too freely and without proper filtration. The sand in the Lower and Upper Roxborough filters consists of particles which will readily pass a brass wire sieve of four meshes to the linear inch, and of which no appreciable part will pass a brass wire sieve of eighty meshes per linear inch. Such material, by the standard adopted by the Massachusetts State Board of Health, would have an effective size varying between 0.30 mm. and 0.35 mm., and a uniformity coefficient varying between 2.00 and 2.60. The sand contracted for for the Belmont and Torresdale filters will have a slightly larger effective size and slightly smaller average uniformity coefficient. The effective size is 0.30 mm. to 0.38 mm., and uniformity coefficient 1.70 to 2.60.

The particles of sand may be pure silica, quartz, or any other material not soluble in water. No chemical action takes place between the grains of sand and the water passing around them. The sand might be replaced with particles of anthracite coal of the same size, and the operation of the filter, in my opinion, would be quite the same, although the use of anthracite coal as a filtering medium would probably increase the sulphuric acid found in the effluent.

Some of the refuse iron sand from the concentrating plant at Edison, N. J.,

was tested in one of the experimental filters at the Spring Garden testing station, but no special advantage for this was found.

Edgar Marburg.—In the construction of these filters, very large quantities of concrete were used. The question as to the best mixing of concrete, especially with reference to the proportion of water, is one concerning which there is still a good deal of difference of opinion. I should like to ask Mr. Hill to tell us something about the specifications for concrete, and whether they led to satisfactory results.

I should also like to inquire more particularly as to the character of the sponge layer at the top of the preliminary filters. That is to say, whether different substances were experimented with, and what determined the final selection.

Mr. Hill.—With reference to concrete, we have adhered rigidly to the specifications as to quality and proportions of materials. There has been a reasonably wide variation in the "wetness" and "dryness" of concrete used, depending upon the location of concrete and the condition of the weather. We have made many cubes and slabs of "wet" and "dry" concrete, and these have been specially tested for strength and water-tightness, and it appears that dry concrete is equally as water-tight as wet concrete, and, on the whole, of greater strength. One objection to the use of wet concrete in the piers of the filters was observed early in the work at Lower Roxborough; viz., upon dumping wet concrete into the tall, narrow forms, the heavier ballast seemed to fall to the bottom as each barrow-load was put in, and when the forms were taken away there was found a layer of stone with very little mortar about it at the bottom and then a layer of finer ballast and mortar above. The amount of water in the concrete was then reduced until the mixture was reasonably homogeneous when placed in the work. The amount of water used has been varied to suit conditions. As a rule the concrete is made as wet as the nature of the work will permit, but always stiff enough to allow the rammers to walk over freshly laid material without sinking in it for more than a fraction of an inch.

Concerning the layer of sponge in the preliminary filters at Lower Roxborough, this layer is 9 inches in thickness, loose, compressed to 6 inches in thickness, equivalent to about 5 pounds per square foot of surface. Other material than sponge has been tried for the elastic layer at the top of the preliminary filters, but on the whole the sponge is less expensive in use, and apparently gives a more uniform efficiency than Holland peat moss. The chief objection to the latter material is that the loss in removing, washing, and replacing is too large to admit of its use in a practical way.

We have frequently washed the dirty sponge from the experimental preliminary filters at the Spring Garden testing station, and the loss of materia, does not exceed 5 per cent. of the original weight, and it is believed that in practice the loss may be kept within 2 or 3 per cent.

An attempt was made to have the manufacturers of mechanical filters make a proposition for the Lower Roxborough preliminary filters, and the specification was so drawn as to admit of a tender on these filters, to operate, of coursel without coagulants; but the bidder was required to incorporate in his proposal a guarantee of efficiency and cost of operation of the filters he offered, and not merely to offer so many filters at a price per filter. I regret to state that

the manufacturers of mechanical filters were unwilling to make a proposition on this work unless permitted to use a coagulant, and, of course, their tender in this way could not be entertained, because the use of a coagulant was, by the terms of the contract, excluded.

I am now reminded of a remark made by his Honor, Mayor Ashbridge, when I came to Philadelphia three years ago to take charge of the plans for the improvement, extension, and filtration of the water-supply, to the effect that "We propose to filter the water of this city, and we propose to filter it without alum; and if you think you can do that, I will hire you; and if not, you can go back to Cincinnati." (Laughter and applause.)

Edw'd S. Hutchinson.—I think I understood Mr. Hill to say that the water of the Schuylkill was somewhat harder than that of the Delaware. I would be glad if he could give us some relative figures on that, if possible.

Mr. Hill.—A comparison of the hardness of the waters of the two rivers from the 4th of January to the 27th of December, 1902, shows 51 parts carbonate of lime per million for the Delaware River and 87 parts for the Schuylkill River. It will thus be seen that the Schuylkill water is about 70 per cent. harder than the Delaware water.

Eugene M. Nichols.—The sponge, Mr. Hill, is it the ordinary sea sponge?

Mr. Hill.—It is the clippings of the ordinary sea sponge. In preparing the Florida and Cuba sponges for the market, large quantities of the sponge are clipped off to give the sponge proper shape. The trimmed sponge is worth ten to twelve cents per pound, while the clippings are sold at five cents per pound. These sponge clippings when compressed *en masse* constitute the elastic layer at the surface or top of the preliminary filter.

Mr. Nichols.—What would be the ordinary life of any piece?

Mr. Hill.—Our experience indicates that the life or durability of the sponge in service will be about nine or ten years. It is thought that the loss will be about 10 per cent. per year, including the waste in handling.

Mr. Nichols.—Well, is not the whole sponge layer calculated, then, as represented by the probable life of a sponge?

Mr. Hill.—Yes; assuming the sponge to have a life or service of eight to ten years, we would be compelled to renew the layer as an entirety in this length of time, due to the natural wear and tear and loss in handling the material.

A Member.—I would like Mr. Hill to tell us how the sand first deposited in the filter bed is treated to prepare it to receive the first inflow of water from the river.

Mr. Hill.—The sand, whether obtained from the Delaware River or from the banks in New Jersey, is washed until the turbidity of the filtered or distilled water in which the sample has been shaken is, by the silica standard, from 200 to 400 parts per million. For this test 100 grams of washed sand are shaken in a beaker containing 1 liter of water. After the filter has been filled to the proper depth with sand of this quality it is worked for one or two weeks at the start to remove matter that cannot be removed by the usual process of washing; the changes which occur in the sand bed may be due, in part, to bacterial action. It is thought that the bacteria which have a natural habitat in the sand may be displaced by certain species of bacteria in the water before the sand bed is ready for the proper filtration of the water. This is simply a thought. What

is well known, however, is that a sand bed improves with age for a period of use of from one to two years, after which the continued use of the sand may show no further improvement, or, as it is sometimes termed, no further "ripening."

A MEMBER.—Is the water passed from the top down, or from the bottom up, in the first filtration?

MR. HILL.—In the final filter?

A MEMBER.—No, in first entering the filter.

MR. HILL.—In charging a plain sand filter originally, and after each scraping of the sand, the water passes from below upward. In the preliminary or roughing filters at Lower Roxborough the water will continuously pass from below upward, the accumulated mud or other suspended matter being partially removed by daily or more frequent flushings. It is not expected of the preliminary filters to deliver or furnish an effluent fit for use, but that it will assist materially in adapting the water for filtration in the final plain sand filter.

MR. HUTCHINSON.—I suppose that crushed quartz will do as well as natural sand?

MR. HILL.—Yes, that would answer the purpose just as well as natural sand.

MR. HUTCHINSON.—I did not know that it was used before.

MR. HILL.—Probably the expense has been the only drawback to its use.

MR. HUTCHINSON.—I have thought that probably the irregularity of the surface of the crushed quartz might give it an advantage over water-worn sand.

MR. HILL.—In a plain sand filter the smoothness or roughness of the grains of sand is of less consequence than the grading of the grains from "coarse to fine." In the sample of sand being used in filters all of the samples should pass a No. 4 and No. 6 sieve, very little should pass a No. 80 sieve, while the size of grain should grade regularly from the coarser to the finer sieve. Each sieve thus in a series, from No. 4 to No. 80, should intercept its proper proportion of the whole sample.

In a preliminary high-rate filter the rough particles of filtering materials are preferable to smooth particles. In the bed of a plain sand filter it does not appear necessary that the grains should be sharp or rough.

MR. SADTLER.—Mr. President, I would like to ask Mr. Hill whether the scum that is formed on the layer of sand is largely suspended matter, or is a fixation of the albuminoid of the constituents of the water; and then, how that scum is removed from the sand.

MR. HILL.—The muddy layer, or *Schmutzdecke*, at the surface of the sand, is largely suspended matter intercepted mechanically. In addition to the mechanical interception of the suspended matter at the surface of the sand there appears to be a useful work going on in the materials of the *Schmutzdecke*, due to the vital activity of the organisms that are intercepted at the surface of the sand and caught in the suspended matter. The *Schmutzdecke* is removed periodically by scraping the bed with wide, flat shovels. The shovel has a flat blade about 12 inches wide by 14 inches long, and is attached to the handle at such an angle with reference to the height of a man that he can push it along horizontally, and we find that men can readily be trained to scrape off a given thickness with very great precision. Usually the scraping is ½ inch thick; sometimes it is much thicker than ½ inch when the applied water is very high in suspended matter.

W. F. Ballinger.—Mr. Hill, as I understand you with reference to bacteria, there is an average of from 11,000 to 16,000 bacteria per cubic centimeter in unfiltered water, and fifty is the standard in the filtered water.

Mr. Hill.—An average for the year 1902 for the Schuylkill River was 14,000 per cubic centimeter of water, and for the Delaware River 6400 per cubic centimeter of water. Fifty bacteria per cubic centimeter of water is the standard we are working to.

Mr. Ballinger.—Then you take out 99.7 per cent.?

Mr. Hill.—It would be so, of course, when the original counts are as high as 16,000; but the percentage would not be quite so great when the number of bacteria contained in the raw water is lower. We are satisfied if the bacterial content of the filtered water can be kept at fifty colonies per cubic centimeter, or less, no matter how few may be in the water originally, and we want it to be no more than fifty no matter how many may be in the water originally; and while the percentages of bacterial and turbidity reduction are stated in the reports of the filters, they are not given the same weight as the actual numbers found upon analysis of the filter effluents. From a careful review of the work of the Spring Garden testing station, reaching back more than two and a half years; of the Torresdale testing station, for one and a half years, and of the Lower Roxborough filters, for the past six months, I feel that there will be no great difficulty in maintaining a bacterial content of the effluent not in excess of fifty colonies per cubic centimeter. Some of our filters at Lower Roxborough are running to-night with a bacterial content of the effluents not in excess of thirty-five colonies per cubic centimeter, and the average of all the filters to-day is very close to fifty colonies.

Emile G. Perrot.—I would like to ask Mr. Hill if a certain thickness of the scum on the top of the sand does not prevent the water from filtering. Is there not a certain limit to the thickness of the scum that would prevent the water from filtering through the sand? And if the pressure is increased on the scum, would not that make the water infectious by carrying it into the filtered water so that it would carry disease?

Mr. Hill.—If, in the operation of the filters, we were to break the *Schmutzdecke* and permit the unfiltered water to pass through the bed, it would be very objectionable; and to guard against this condition the utmost care is displayed in distributing the sand when first placed in the filter. If there be negligence in placing the sand in the filter, and a condition of the effluent should arise indicating the passage of unfiltered water from the top to the bottom of the sand bed, there probably would be only one remedy for this—viz., to take the filter out of service, remove and properly replace the sand. The placing of the sand in the filters has been as rigorous as the testing of cement, steel, or other materials offered for use in the construction of these works.

I fully realize the danger inferred in the question, and have taken every possible precaution, first, to bring about a sand bed of uniform density throughout; second, to so guard the operation of the filters as to avoid disturbance of the sand bed while in use.

Considering the homogeneity of the sand, I do not think the *Schmutzdecke* could be broken by the pressure due to the maximum rate of filtration which we may employ. In the operation of the filters it is run until the loss of head becomes so great that it cannot be operated at a profitable rate of delivery.

MANUFACTURE OF CEMENT FROM MARL AND CLAY.*

HENRY S. SPACKMAN.

DISCUSSION.

The President.—Does any one wish to ask any questions?

A Member.—What is the object in drying clay before mixing in the marl?

Mr. Spackman.—In order to make a better mix. The water in the clay varies considerably, and in mixing up wet it is difficult to tell the percentage.

A Member.—Could they not determine the percentage of water in the clay in the first place?

Mr. Spackman.—They could, but with each new clay it would mean determining the moisture.

A Member.—Would not that be cheaper than drying it out?

Mr. Spackman.—It might be, but is not generally done.

Wm. C. L. Eglin.—How is that water taken care of?

Mr. Spackman.—It evaporates—goes out with the fuel gases.

A Member.—May I ask how the marl cement compares in quality with the Lehigh cement?

Mr. Spackman.—I think it will compare favorably. Some of the marl cement is not as good as the Lehigh cement, but that is because a great many of the mills in the West have just started; I know of one mill that started operation in which there was not a man who had ever been inside of a cement mill. I didn't know a man who would start in the shoe business or in the iron business without experience, but they will go into the cement business on that basis.

Richard L. Humphrey.—There are a number of features in Mr. Spackman's paper on which I would remark.

In reference to the capacity of rotary kilns in the wet process, I would state that this capacity ranges from 80 or 90 to 175 barrels per kiln per day, with a coal consumption ranging from 150 to 250 pounds per barrel. The capacity of kilns in the wet process depends to a large extent on the quantity of water used in producing the slurry; this ranges from 35 to 65 per cent., with an average of about 50 per cent.

The mills located at Newaygo, Michigan, and Syracuse, Indiana, are the best types of marl mills. In the latter the capacity reaches 155 barrels per kiln per day.

The plant at Alpena was originally designed as a marl mill; they are at present using a very pure coral limestone, and with 35 per cent. of water obtain from 145 to 160 barrels per kiln per day.

The more liquid the slurry, all other conditions being the same, the smaller is the output of the kiln.

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* Mr. Spackman's paper appeared in the April issue of the Proceedings.—Publication Com.

The chief difficulty in the wet process is the large quantity of water that must be handled and evaporated in the kiln.

Marl is a very difficult substance to dry; it has great hydroscopicity and gives up its moisture very slowly. A piece of marl placed on a red-hot plate for ten or fifteen minutes shows little loss of moisture. If, however, it is fanned or subjected to a current of dry air, the process of drying is greatly facilitated. Two things are essential, therefore, for the rapid drying of marl: (1) heat and (2) a constantly changing current of dry air.

Many attempts have been made to utilize the waste heat in the wet process kiln, the most successful being the lengthening of the kiln, making it 110 feet long, resulting in a decided increase in the output.

In some mills, notably those in Canada, the attempt is being made to dry the material prior to its introduction into the kiln, thus having dry material to burn. In these mills the drier is equipped with an exhaust fan which quickly removes the moisture and furnishes a regular quantity of dry air. A novel modification of this scheme is in the plant near Bay City, which was referred to by Mr. Spackman, in which the marl is dried at the bed and then transported to the plant.

The plant at Iola, Kansas, using limestone and clay under the wet process, obtains 175 barrels per kiln per day; the novel feature being the use of natural gas in the kilns for burning and to run the gas engines which furnish the power.

Many theories have been advanced as to the origin of marl, the most plausible of which seems to be the subterrain spring theory Under this theory it is held that the waters of these springs, many of which are under considerable pressure and are very cold, carry under such conditions considerable quantities of lime in solution. The decrease in pressure and the increase in temperature which result from their contact with the warmer water of the pond or lake into which they discharge precipitate the lime. Again, certain forms of algæ give off carbonic acid gas, which precipitates the lime.

Nearly all the marl deposits in Ohio and Indiana, and most of those in Michigan, owe their origin to these causes.

I think the quantity of marl formed by the decomposition of molluscan shells is very small indeed, and could never satisfactorily account for the immense deposits of marl.

As regards the methods for handling marl, there are one or two which have not been referred to by Mr. Spackman which are interesting. For example, at Syracuse, Indiana, the dredging is done with a continuous bucket elevator. The scow bearing the machinery which operates the dredges is moved over the marl bed in regular lines and the marl is excavated to a uniform depth, the process being similar to that of ploughing. The marl goes into a hopper over a pug mill, in which sufficient water is added to reduce it to a slurry of syrupy consistency. It is then forced by compressed air through a ten-inch pipe to the plant a distance of several thousand feet. Here the proper percentage of clay is added and the mixture ground to an impalpable powder.

At Coldwater, Michigan, the marl is dredged and dumped into a pug mill, in which it is reduced to a slurry which flows into the bottom of the scow. When the latter is filled, it is towed to a dock near the plant and the slurry pumped out of the scow into the storage tanks in the mill.

In most plants the marl is handled by means of pumps, of either the centrifugal or the plunger type. In plants of the latest type these pumps have been very successfully replaced by compressed air; compressed air being used for agitating the slurry as well as for pumping.

The cost of producing cement by the marl process is excessive, and several years ago the low prices at which cement sold brought many of these companies to straitened financial conditions. These mills, however, receive a fresh impetus during the era of high prices of the last few years, and many, I believe, are making money. As the price recedes, however, these mills are brought into keen competition with the dry rock mills; they are seriously affected, and can only find a profitable market locally or at such points where, by reason of lower freight rates and lack of competition, they have a monopoly.

The cost of manufacture, as Mr. Spackman states, is much greater than in the dry rock process. This is due to the quantity of water that must be handled and finally evaporated from the slurry, which requires in this kiln nearly double the amount of coal, with an output from the kiln of less than half. Again, extreme cold weather freezes the marl beds, and many plants are shut down for two or three months each year. Where the marl is covered with a considerable depth of water, as at Syracuse, Indiana, it is possible to work all winter by breaking up the ice as it forms on the lake. The use of steam to prevent freezing at the marl bed is in vogue at some plants, but with indifferent success.

Another bad feature is the available quantity of marl. Most plants have large areas of marl land; but as the depth varies from a few inches to twenty or more feet, and as in many cases it does not average five feet, the supply is rapidly exhausted. Several mills, for this reason, will be obliged to permanently shut down.

As a cubic yard of marl will yield about four barrels of cement, it is readily seen that a large quantity is required in a plant of any size.

A mill to be successful at the present time should have a large capacity, for it is in large plants that cement is manufactured most economically.

For a number of years marl plants were built in the West, and particularly in the State of Michigan, with mushroom-like rapidity. The difficulties encountered by these new mills have checked their growth, and only in a few instances have the plants been enlarged, the development now being principally in the dry rock process.

The growth and development of the Portland cement industry in this country in the last twelve years have been very remarkable. From a production of about 350,000 barrels in 1890, it has grown rapidly until it now exceeds 14,000,000 barrels, while this country has moved from the fifth to the second largest cement-producing country of the world, being exceeded by Germany only. At the present rate of increase in production it will not be many years before the United States will be the largest cement-producing country in the world. The methods have been so perfected and the quality so greatly improved that we excel all other countries; so much so that these countries have been forced to adopt the American methods.

Mr. Spackman.—In regard to Mr. Humphrey's remarks about drying of marl in the manufacture of cement, would state that we received a letter from

the mill in Canada to which I think he refers, in which they asked us whether we could suggest any improvement in their method. We quote from their letter as follows:

"Our system is the dry, using wet marl and clay. We dry the marl in a rotary drier, the same as a rotary kiln, using powdered coal for fuel."

I have been informed since the receipt of this letter that they had been compelled to abandon the drier originally installed, and use one of the rotary kilns for drying the marl, thus cutting down their production, but do not know whether this is correct or not.

I was also advised by the superintendent of another plant which also dries its marl before manufacture into cement, that they had considerable trouble at first, and would quote from his letter as follows:

"The driers have given very good satisfaction with the exception of the two marl driers which have been obliged to work above their capacity, and they have given us considerable trouble. Their first cost is very high and they are very expensive to keep in repairs. Although we did not originally install enough drying machinery to bring the plant up to the capacity contemplated in the original installation, we are at present installing additional machinery which will bring our plant up to at least 500 barrels per day. We believe we have made the dry process a success, inasmuch as we have a very granular marl which is easy to dry, differing considerably from the marl used in Canada, which plant I visited a month ago. From what I saw I do not believe they will be able to make a success of the manufacture of Portland cement from marl and clay by the dry process, for the simple reason that their marl is of a putty nature and not easily dried."

I would also state that this mill has very large storage sheds in which they store marl for partial air-drying before it is sent to the driers.

Mr. Humphrey.—Is that correspondence quite recent?

Mr. Spackman.—Within the last week. I started to write this paper about three weeks ago, and in order to be certain of my facts, I wrote in order to ascertain the latest results obtained in these two mills.

Mr. Humphrey.—In drying marl, or, in fact, any material containing an excessive amount of water, the question of heat is not so important as is a regular current of dry air. Driers equipped with exhaust fans are for this reason the most efficient.

Mr. Spackman.—Did you say 190 pounds of coal with a 110-foot kiln? I do not think that is as well as they are doing elsewhere. I think Mr. Humphrey is right that the low capacity is not entirely due to bad burning, but also to the character of the materials. Yet I have seen an increase of 25 per cent. in production of the kiln by change of burners. For the Michigan kilns eighty or ninety barrels is not bad. One hundred and fifty is exceptionally good for the wet process. I also think the estimate of cost, $1.10, is high. I have two that cost eighty-eight cents, based on one month's running.

James Christie.—An interesting circumstance in connection with the use of rotary kiln in cement manufacture, and illustrating how rapid the evolution of processes are nowadays, can be found by referring to our Proceedings of 1893. The rotary kiln is there described as a novelty, and its utility was questioned by members who were high authorities on the subject of cement manu-

facture. I think our critics of that period use nothing but the rotary kiln now.

Mr. Spackman.—Mr. Humphrey was speaking of the labor cost. I had occasion to compare the cost per barrel, not the hours of labor. The total labor cost in New Zealand, Germany, and in this country is almost identical. Figures were given when they were considering the use of the rotary kiln.

A Member.—In the burning of the coal, what becomes of the ash?

Mr. Spackman.—Each particle becomes less than a thousandth part of an inch. Where the ash goes we don't know.

Mr. Humphrey.—The ash of the coal used in burning Portland cement does not seriously affect the quality of the cement Aside from a decrease in the number of heat units with the increase in ash, the ash is not an important factor. This ash does not enter into the chemical reactions which take place in the kiln, but adheres to the surface of the clinker. It slightly increases the percentage of silica in the chemical analysis. It has been attempted many times to make a correction in the mixture for this ash, but it was found that it did not in any way enter into the reactions, and that mixtures so corrected were not properly proportioned to clinker well.

Mr. Spackman.—We have found the same apparent increase in the silica over that which theoretically should be the result of burning the raw mix, but have not found this percentage to vary with the percentage of ash in the coal, the same relative increase in silica which is fairly constant in each mill being observed when the ash in the coal varies from 7 to 15 per cent., and I have always been at loss to account for the final disposition of the ash, but believe it goes out of the stack with the flue gases. In some cases the dust in the stacks is considerable and causes annoyance to the people living in the neighborhood of the mill.

James Christie.—Can our friends engaged in the cement manufacture ex-explain why natural cement loses its initial strength after the first week or two? We have tested large quantities of concrete beams, and invariably notice this loss of strength with the concrete in which the natural cement is used. Of course, it shortly regains the original strength, but acquires its maximum resistance more slowly than when Portland is used. We have never observed this loss of strength with the Portland cement.

Mr. Humphrey.—I must confess that my experience has been quite to the contrary. Natural cement concrete hardens very slowly, shows no loss of strength, but after a number of years attains excellent strength. Portland cement concrete hardens much more rapidly and attains very much greater strength for a short period of time. Portland cement tested for tensile strength shows a loss in one or more months; it then commences to increase in strength. Natural cements, particularly with sand, show a progressive growth of strength and after five or six years often greatly exceed in the sand tests the neat strength. Natural cement does not acquire sufficient early hardness, and generally it is impossible to depend on the strength it will acquire after several years, as most structures of the present day receive their ultimate load at once. Were the test pieces mentioned preserved in air?

Mr. Christie.—Sometimes in air and sometimes in water; almost all in air.

Mr. Spackman.—In one plant which we built, where they intended doubling the capacity, they put in producers experimentally. As far as actual running was concerned, there was little difference; the production per kiln was about the same and also the coal consumption. During the trial two kilns were operated with producer gas and two with powdered coal. They found that it took about two pounds more coal per barrel of cement produced using producer gas, but the labor cost for attending the producers was considerably higher, and they had to use a higher priced coal; where in the kilns using powdered coal, ordinary slack could be burned, and they figured out there was quite a saving in favor of the kilns using powdered coal. This test was made some time after we had turned the mill over to our clients, and I am not familiar with the details.

THE RICHARDS PRISMATIC STADIA AS A RANGE-FINDER.

E. K. LANDIS.

Read April 4, 1903.

I DESIRE to call the attention of the Club to a new use of an old instrument—viz., the Richards prismatic stadia.

This instrument was invented by Prof. Robert H. Richards, of the Massachusetts Institute of Technology, and fully described by him in a paper read before the American Institute of Mining Engineers, in October, 1891.

This instrument is so simple and so accurate, that it is a great surprise to me to find it almost unknown to most engineers of my acquaintance, especially as nearly all transits are now provided with the wire stadia, which does not compare with it in accuracy, and which cannot be used at all in the manner mentioned below.

A full description of the instrument and its uses (except as a range-finder) will be found in the "Transactions of the American Institute of Mining Engineers," volumes XX and XXI.

My first experience with the Richards prism was in 1894, when Professor Richards exhibited the instrument and explained its uses at the Virginia Beach meeting of the American Institute of Mining Engineers.

The simplicity of the instrument and its advantages over the wire stadia were quite apparent, but did not come within my scope of work at that time. In 1896 my attention was again attracted to the subject, and, wishing to see what the instrument could do, I had a small one constructed in order to determine its possibilities. This prism was a non-achromatic one, and the intention was to give it a throw of 1 in 50; but when standardized the throw was found to be 1 in 52.25.

In experimenting with this prism one evening it was directed at the moon, and there appeared in the field two images of the moon, separated by an interval slightly larger than the diameter of the moon itself. At once the idea struck me that it would be possible to determine the distance to the moon, using the moon's diameter as a base. The throw of the prism was slightly over two diameters

of the moon; and, calling it two, then twice the diameter of the moon in miles multiplied by the throw of the prism would give the distance from the earth to the moon! This was done, and gave 96 per cent. of the true distance, showing the idea to be correct, as this result was based on a throw of two diameters, while the actual throw was slightly over two. It then occurred to me that it would be possible to measure the distance to any object, if some dimension of that object were known, and many experiments were made to test this opinion.

In June, 1901, Professor Richards was kind enough to present me with a prism having a throw of 1 in 100, and considerable work has been done with this one, with very satisfactory results.

In preliminary survey work it sometimes happens that a knowledge of the distance to some point would be of value if it could be obtained quickly and without the trouble of running a line with a transit, or sending a rodman; and if the point is a house, barn, rail-fence, or something whose dimensions are known, or can be approximated, the distance can be determined with a fair degree of accuracy by using the method mentioned above. In many cases this would be enough to show whether it would be worth while to divert the line toward the point or not.

An engineer possessing one of these instruments could use it on his transit telescope in regular stadia work, and by slipping it on a hand telescope could use it in the manner outlined above, thus gaining much valuable information without the expense of an additional instrument.

While the prism can be used on a transit or a hand telescope for stadia work, I have found it to work better for range-finding purposes when used on a Trieder binocular, as this seems to give better illumination, and, besides, it is much easier to follow a moving object with a binocular than with a telescope.

As a military range-finder it would seem to be of use where it might be required to get the range without unmasking the position, which in many cases could be easily accomplished. This would be almost impossible with any of the range-finders now used in the United States army, the simplest one (the Weldon) requiring a comparatively level and open piece of ground, which is not always to be had, and the help of an assistant. Moreover, the Weldon would be useless in ranging a moving object, which presents no difficulty to the Richards prism.

As a naval range-finder it seems to me to be in advance of anything yet offered, as it is possible, within less than half a minute, to tell the distance of a ship, lighthouse, or point of land, and quite as accurately as from a cross-bearing, which latter would require some length of time in taking, and, if the object were a moving ship, the results would not be accurate.

My experience has shown that it can be used in many cases with as great accuracy as a sextant measurement (taken on and off the arc), and does not require a skilled observer, any man of ordinary intelligence being able to do good work after a little practice.

Below are given some results obtained with the instrument, and in every case where it was necessary to obtain a datum from others, this was done before the result was worked out, so as to avoid any bias whatever.

One great advantage of this instrument over the sextant is that the jar or vibration of the machinery, and the rolling and pitching of a ship in rough weather, do not prevent its use, while they render it very difficult to get any reliable results with a sextant.

In order to facilitate the reading of the prism throw, a piece of glass having a scale of equal parts engraved upon it was placed in the focus of the eyepiece, but this was found to absorb much of the light, and in most cases proved unnecessary.

Range-finder Sights.

Lake Superior, June, 1901. On board the steamship "Minnie M." Sighted the white stone shaft of a lighthouse on the north shore. Shaft 40 feet high. Prism throw three diameters; distance 12,000 feet, or 2.27 miles. The First Officer gave 2.25 miles by dead reckoning.

West Point, N. Y., October, 1901. From the front of No. 11 quarters in "Officers' Row," to the front of Cullom Hall. Base taken; height of window in Cullom Hall, estimated by one of the officers as 12 feet. Prism throw one and a half diameters, distance 1200 feet. Scaled on Professor Larned's map, 1275 feet.

Port Antonio, Jamaica, February, 1902. Measurement of distance between the old fort and Folly Point lighthouse. Base taken, total height of lighthouse tower, which was divided into four bands of different colors. Tower 35 feet high. Prism throw three-quarters of total height. Distance by range-finder, 2625 feet; by sextant (on and off), 2622 feet; by chart scale, 2631 feet.

The following is a sample of what can be done at night: On a trip

to Jamaica, while off Watlings Island, about 10 P. M., we passed a steamer on the starboard, bound northward. When just abeam, the prism throw raised the row of deck cabin lights to a level with the masthead light. This base was estimated by the Captain as 35 feet; therefore the distance was 3500 feet, which slightly exceeded the Captain's estimate of half a mile.

Range-finder Sights on Board the Steamship "Montauk Point," 1902.—June 24th. At 6.30 took a sight at a full-rigged ship to the starboard, just abeam. Base taken, truck to water-line, estimated by Captain as 120 feet. Prism throw two diameters, or 240 feet; therefore, distant 4.54 miles (4 knots).

June 27th. At 12.30 noon passed a tank steamer to the starboard, bound westward. Base taken, length over all, estimated by Captain as 320 feet. Prism throw one and one-eighth diameters; distant 36,000 feet (6 knots).

July 1st. At 12.50 P. M. Weather quite foggy. Passed a bark under full sail to the starboard, bound eastward. Base taken, total hoist of spanker, estimated by Captain and Second Officer as 20 feet. When just abeam, prism throw was half a diameter, or 10 feet; distance 1000 feet. Captain's estimate was 600 feet.

July 4th. At 10.30 A. M. took a sight at the Bishop Rock lighthouse, dead ahead. Base taken, height of tower, given by Captain as 183 feet. Prism throw two and a quarter diameters; distance 6.77 knots.

At 2.20 P. M. Wolf Rock lighthouse, bearing about 30 degrees forward of the beam. Base taken, total height of light above water, given by Captain as 135 feet; distance 13,500 feet, or 2.22 knots. When just abeam, prism throw was total height of light, less height of post on wharf alongside, above water. My own estimate of post is 18 to 20 feet. Distance 11,500 feet, or 1.89 knots. Angle by calculation, 31° 35′.

Range-finder Sights on Board the Steamship "North Point," 1902.—July 19th. At 3.40 P. M., just abreast of the Eddystone light. Height 148 feet. Prism throw about three diameters; distance 7.3 knots. Ship's log gives 7 knots by 4-point bearing.

At 5 P. M. passed a large bark to port, bound westward. Prism throw, mainmast on foremast, horizontally. Distance between masts estimated by First Officer as 70 feet. Distance 7000 feet, or 1.15 knots.

July 23d. At 10 A. M. passed a tank steamer to starboard bound

eastward. Base taken, truck to water-line; estimated by First Officer as 130 feet. Prism throw two diameters. Distance by range-finder, 4.44 knots; by sextant, 4.25 knots.

About 4 P. M. passed a bark to port, bound eastward. Base taken, truck to water-line, estimated by Second Officer as 120 feet. Prism throw two diameters. Distance 3.95 knots. The Second Officer estimated the distance as 4 knots.

July 25th. At 10.30 A. M. passed a steamer on the port side, bound eastward. Prism throw when abreast was two diameters top of funnel to deck, or funnel to foremast horizontally. Our funnel is 38 feet high. First Officer estimates mast to funnel as 75 feet. Distance by vertical base, 7600 feet; distance by horizontal base, 7500 feet.

July 26th. At 8 A. M. ranged a full-rigged ship on our starboard bow. Base taken, truck to water-line. Prism throw five diameters. When 30 degrees forward of the beam, prism throw one diameter. When abeam, prism throw, water-line to middle of royal. Estimated by officers as 150 feet from truck to water-line, and 12 feet less to middle of royal. First sight, 75,000 feet, or 12.34 knots; second sight, 15,000 feet, or 2.47 knots; third sight, 13,800 feet, or 2.27 knots. Sextant measurement by First Officer gave 2.6 knots for second sight.

July 27th. A large four-masted steamer overhauled and passed us to port. When 40 degrees forward of the beam, and crossing our course at an angle of 20 degrees, prism throw horizontally was one diameter of total length, estimated by First Officer as 450 feet. Distance 42,500 feet, or 6.99 knots. The First Officer estimated the distance as 7 knots.

THE OBSTRUCTION OF THE NAVIGATION OF SOUTHERN RIVERS BY THE GROWTH OF THE WATER HYACINTH.

L. Y. SCHERMERHORN.

Read April 4, 1903.

THE attention of the national government was directed a few years ago to the obstruction of the navigable waters of Florida and other South Atlantic and Gulf States, by the aquatic plant known as the "water hyacinth," and an examination was ordered by Congress to determine the extent of such obstructions, and what action, if any, should be taken to provide against the closing of these navigable waters by the continued growth and spreading of this plant.

Official attention was first directed to this subject in 1895, by the commercial interests of the St. Johns River, Florida, and at that date it was stated that the water hyacinth made its appearance in the river about 1892, and that in 1895 it had so filled the river in places as to render navigation very difficult. In 1896 it had obstructed the St. Johns River to such an extent that at certain localities it covered the river "from shore to shore in masses, that neither steamboats, schooners, nor any kind of water craft could make their way" through it. On many of the tributaries of the St. Johns River water communication has been practically abandoned, and rafting operations have entirely ceased, and in places on the main river it is dangerous to attempt to cross in small craft, even when the opportunity appears favorable.

Subsequently its appearance was noted in other rivers of Florida and the Gulf States, where its rapid development resulted in such an obstruction of navigable waterways as to demand and receive the attention of the national government. During the last few years Congress has made substantial appropriations for the purpose of arresting the spread of the plant, and for removing it, if possible, from localities where it had become a barrier to navigation; but so far these efforts have not been eminently successful.

Figure 1 graphically represents the character and extent of the obstructions which have resulted from the growth of the water hyacinth in the waterways under reference.

The plant is known to science as the *Eichhornia crassipes*, or *Pon-*

tederia crassipes, and somewhat resembles the common pickerel weed known in the South as *wampee*. In tropical and subtropical America it is a common and widely distributed aquatic plant. The individual flowers are about one and one-half inches in diameter, of a lilac-rose color with a yellow spot on the uppermost petal, and are arranged in the form of a spike about five inches in length. The leaves are broad, and nearly circular, growing in the form of a large rosette from one to four feet above the surface of the water. The stems of the leaves are enlarged near the surface of the water into oval

Fig. 1.—Bridge at Palatka, Showing Three Small Steamers Attempting to Make Their Way through a Mass of Hyacinths.

swellings filled with air-cells, which serve the double purpose of adding buoyancy to the plant and strength to the stems. The roots are fibrous and numerous, forming a dense, bushy mass with a central, wire-like stem, from all sides of which feathery filaments project from one-half to an inch in length; the entire root-stem varies from one to two feet in length. The plant commonly floats on the surface of the water without its roots being attached to the soil; though in shallow water such an attachment may result; but in these cases the plants do not grow so large as when floating.

The plant is propagated from the seed, and also by runners starting from the crown of leaves just below the water surface; in this manner large masses of the plant grow together, and remain intact as they drift from place to place under the action of the wind or the river current. The plant requires either fresh or brackish water for its growth. Sea water destroys it after a prolonged immersion.

The water hyacinth is probably an exotic, but the history of its introduction into the United States is not well established. It is a native of Venezuela, and it is stated that it was introduced into this country, as an ornamental plant, many years ago; other authorities state that it was imported from Europe about ten years ago and planted in a small pond near Palatka, on the St. Johns River from which it escaped into the adjacent river. At the present time its growth seriously threatens the navigation of streams in Florida, Mississippi, Louisiana, and Texas, by the formation of a dense, floating aquatic growth covering waterways to such extent that even steamboats are unable, at times, to force a passage.

Congress has appropriated about $90,000 for the study of the problem of the eradication of the water hyacinth, and for carrying into effect experiments therefor. The methods which have been tried may be divided into two classes—viz., the use of mechanical means, and the use of chemicals destructive to the plant.

The mechanical means consisted in breaking the packs apart, and loosening them from the shore, with the hope that the river currents would carry the plant away; this has been only partly successful, on account of the opposing effect of the wind and the sluggish currents of the streams. Efforts were made to surround masses with heavy nets, and by the use of tug-boats tow the impounded mass into salt water, but when a heavy strain was placed upon the net, the plants crowded over it, sinking the float-lines so that the plants could not be retained.

Recourse was then had to specially constructed boats with machinery arranged to cut and crush the roots and stems and thereby destroy their further growth. While this method was efficient as far as it went, it was found to be too slow and expensive to be considered practical as a general solution of the problem.

Experiments were then made with the view of destroying the plant by spraying with various acid solutions, with steam, hot water, and with kerosene oil. Beyond killing the tops of the plants, these methods were a failure, since the unimpaired roots quickly restored the leaf growth of the plant.

The idea was suggested of pitting nature against herself, through the introduction of some animal or parasitic growth injurious to the plant, but in the light of precedent this was not considered an advisable experiment to undertake. The introduction of the English sparrow into the United States, the rabbit in Australia, and the Australian lady-bug in California, to kill the white scale on orange trees, are notable instances of the danger of such innovations.

Latterly, attention has again been directed to the destruction of the plant by spraying with a cheap compound, the composition of which is not made known. Experiments recently made with this material indicate that one-twelfth of a gallon per square yard was sufficient to thoroughly destroy the plant; the cost of this method is estimated at about one-third of a cent per square yard treated. With a suitable boat fitted with tanks and spraying apparatus, about 40,000 square yards could be sprayed in a day's work, in large fields of the plant. While the problem of the destruction or checking of the water hyacinth is as yet unsolved, the amelioration of the conditions surrounding the subject is more confidently anticipated in the method last described than in any other which has been suggested.

The extent to which this aquatic plant has increased during the last few years is fully realized by the government, and Congress, under the conviction that the interests of navigation are deeply involved, has authorized appropriations to secure its extermination by mechanical, chemical, or any other means.

DISCUSSION.

The President.—We shall be pleased to hear from any of the members present.

Eugene M. Nichols.—I should like to ask Mr. Schermerhorn whether that growth is anything like that in the Nile.

Mr. Schermerhorn.—No, entirely different.

Carl Hering.—Among the methods that Mr. Schermerhorn suggested for exterminating this weed, he did not mention the application of an electrical current. It seems to me that it might be quite feasible to try the electrical method, as we know from experience that plants as well as animals are very readily killed by an electric current when properly applied. If, for instance, an overhead wire of a lighting or trolley circuit is in contact with the limb of a tree, and the insulation has been rubbed off, the limb will very likely die. I have seen many cases of that kind. If the current were passed in the proper direction through this weed, it seems to me that a relatively small amount of electrical energy might suffice to kill a very large quantity of this growth. The

current would have to be applied correctly, probably in the direction of the fiber. As an illustration of a similar application, I might mention here that the electric current has been used to kill the weeds that grow between the tracks of a railroad; there was a dynamo and a transformer for raising the voltage, on the locomotive; one pole was attached to a bar held in front of the train just a little above the level of the tracks: the ground was connected to the other pole through the rails. All the weeds that were touched by this bar as the car passed over them, had a momentary current passed through them and were destroyed.

The objection was raised that the current would probably be conducted largely through the water. That may be true, but I think it is more likely that the majority of it would be conducted through the stems and even the roots, because they probably have a lower resistance than the water. If one pole of a high voltage transformer, carried on a boat, were connected to the water and the other to a horizontal bar having numerous short, flexible wires attached to it like a comb, and if this comb were trailed over the parts of the plants which project above the water, the current would have to pass through the stems in order to get into the water; it would thus kill the projecting parts, and probably also those that are submerged. The method is so very simple that it seems well worth trying.

The President.—I should like to ask Mr. Schermerhorn whether the Southern waters in which the hyacinth grows are sluggish, or whether there is a current.

Mr. Schermerhorn.—The waters are very sluggish indeed. As you understand, the water hyacinth does not attach its roots to the soil. The roots are not bulbous. The plant is kept in its floating condition by air bulbs or globes along the lower leaves which support the plant upon the surface of the water.

Sam'l S. Sadtler.—I should think there might be some nitrifying bacteria that aided the roots in taking up the nourishment. Maybe if some antiseptic were put in the water, the object of destroying these plants might be attained without seriously changing the value of the water and taking excessive amounts of chemicals. Sulphate of aluminum might be effective in such a case.

Mr. Hering.—There is still another possible way of exterminating the plant—namely, to find some use for it. Perhaps the stems of this plant have sufficiently strong fibers to be of some use.

E. K. Landis.—Has kerosene ever been tried as a means of killing it?

Mr. Schermerhorn.—Kerosene oil has been sprayed upon the plant, but not, probably, in sufficient quantities to admit of its being subsequently burned upon the surface of the water; its expense upon so large a scale would preclude such a method.

F. E. Dodge.—The waters, especially in Florida, have considerable vegetable matter in them. They are pretty nearly coffee color. The picture of the St. Johns River at Palatka is very natural. I can appreciate the water hyacinth in Southern waters. These Florida rivers get some of their water from springs which are quite strongly impregnated with sulphuretted hydrogen. Some of these springs are very large. One that I am familiar with on the St. Johns River is thirty or forty feet in diameter and water enough comes from it to run a mill. They have an undershot wheel and it runs a grist mill.

Charles Hewitt.—I would like to ask Mr. Schermerhorn if this plant dies out annually or whether it is a continuous growth throughout the year.

Mr. Schermerhorn.—It is of continuous growth. It is a very succulent plant. I hardly think there is any fiber in its leaves. It has been gathered in large quantities to keep it within limits, but in a few days it simply falls apart as a mass. There is hardly any fiber in it.

Mr. Landis.—Will cattle eat it?

Mr. Schermerhorn.—It is said that cattle will eat it and that it was handled by some of the cattle men as a possible food for cattle. That is not very much substantiated. I think that it was introduced as an ornamental plant.

Mr. Landis.—Do you know of any specimens in Philadelphia?

Mr. Hewitt.—There is some at Willow Grove. I do not know whether it is the same plant or not. It is a water hyacinth, and it grows very luxuriantly. It has to be kept in by a wire net. I think it is replanted every year—torn up in the fall and planted in the spring. I know the plant does not exist in the winter as a green plant. Whether it grows from the same seed or not I cannot say.

THE MILITARY IMPORTANCE OF NAVAL ENGINEERING EXPERIMENTS.

REAR-ADMIRAL GEORGE W. MELVILLE, U. S. N.

Read May 2, 1903.

THE act making appropriations for the naval service for the fiscal year commencing July 1, 1903, contained a larger appropriation for new construction than any act heretofore passed by a Congress of the United States. This act not only provided for the construction of three first-class battleships of not more than 16,000 tons, and two first-class battleships of not more than 13,000 tons displacement, but it likewise authorized the building of a naval engineering laboratory whose cost, including equipment, should not exceed $400,000.

COST AND DEPRECIATION OF MODERN BATTLESHIPS.

The hulls and machinery of these five battleships will cost approximately $20,000,000. The armor, armament, and equipment will require an additional outlay of $15,000,000; so that the actual cost of these battleships will probably be about $7,000,000 each. The annual depreciation of each of these vessels from the time they are launched, taking into consideration wear and tear as well as loss in fighting value, will be at least 4 per cent. of their actual cost. The expense attending the establishment of the proposed experimental station, including its operation for several years, will thus be but little more than the annual loss resulting from corrosion, mishaps, and depreciation of military appliances of two of these floating fighting machines.

THE EXCELLENCE OF GERMAN NAVAL AND MARITIME CONSTRUCTION.

The rise of Germany as a naval and maritime power during the past thirty years has surprised the world. I believe that her battleships for their tonnage are the best afloat, because they possess a triple-screw installation of machinery, thus giving the motive power of her larger warships economical, structural, and tactical advantages over similar high-powered vessels of rival nations. Her ocean greyhounds are the largest, fleetest, and probably the most economical and comfortable afloat. Strangest of all, this excellence in the con-

struction of warships, as well as in the building of vessels for the ocean-going trade, is not the result of a progressive series of failures, either in design, construction, or of operation.

The success of Germany can be accounted for only by recognizing the fact that study, reflection, and research must have been expended in the preparation of plans, in the building up and the organization of the shipyards, and in laying out and carrying on the work of construction. It was the high appreciation of the value of original investigation, coupled with experimental work, that has caused Germany to advance progressively and successfully. Patient investigation and carefully conducted experiments were required by the Berlin Admiralty, for these officials believed that unless such research was thoroughly conducted, the building up of any navy and its mercantile marine could be accomplished only after discouragement and possibly disaster had been encountered. Where research had not been conducted, disappointment resulted from the construction of vessels which were either faulty in design, ill suited for the purpose intended, or upon which an inferior quality of work had been expended.

For over a hundred years Germany, as a nation, has carried on more original research along technical lines than any other power. While it is true that both England and America have put to practical application the principles discovered by German research, thereby gaining commercial and maritime advantages, it has been the Teuton who has sought after principles, and thus the world is primarily indebted to this studious and thoughtful race for many of the great discoveries and inventions.

The Naval Experimental Work of America and England has been of a Sporadic Character.

In a desultory and sporadic manner all naval powers have done some experimental work. It is because original investigation is not always appreciated in its fullness by the Anglo-Saxon that many administrative executive officers are indifferent to such research, and therefore experimental tests in Great Britain and America are not always of a continuing nature. Great Britain, however, has recently been compelled to establish a National Physical Laboratory, because the encroachment of continental rivals threatened to interfere with her foreign markets. It can hardly be said that she has done this work in a manner that should be duplicated by us; since it has been

affirmed that in this laboratory the standard measuring machines are installed in a basement room, the walls and ceilings of which are of rough brick, full of deep crevices in which dust can, and will, of course, collect. Better do no scientific work than not do it well, is the maxim of the German.

Thirty-five years ago Engineer-in-Chief B. F. Isherwood, U. S. N., carried on an extended and careful series of experiments in connection with the subject of screw propellers. The information secured at that time is standard authority to-day; but since then it has required persistent effort to arouse naval administrators to the importance of detailing ships and men for securing data upon questions relating to the action of the screw propeller.

The problem as to whether or not in-turning screws are detrimental to manœuvering qualities would have been solved many years ago if the work planned by Mr. Isherwood had been continued. Our increased knowledge of the theory and practice of screw propulsion since the Isherwood experiments is due, however, almost wholly to the work of Froude, conducted for the British Admiralty. This is confirmatory evidence that such important and difficult work can only be undertaken by official or civilian experts who are able to call upon government resources for data and information. It requires government investigation to solve important problems relating to the powering of vessels, since valuable and far-reaching experiments upon this subject require the use of ships as well as the services of a large number of reliable and competent persons to collect the data requisite for the determination of absolute results.

Experimental Work Done at the Naval Academy.

With a thorough realization of the importance and necessity of securing data upon screw-propeller problems, the head of the Steam Engineering Department of the United States Naval Academy, now Captain C. W. Rae, U. S. N., assisted by the instructors in his department, commenced in 1895 what promised in some respects to be an extended investigation of the problem. These tests were interrupted by the demands of the Spanish-American war, since everything at the Naval Academy had at that time to be subordinated to hastening the graduation of the senior classmen.

The plant consisted of a small triple-expansion engine, turning a shaft upon which was fixed a propeller submerged in a tank of water. This tank was so arranged that the column of water driven forward

or back, depending upon the direction of motion of the engine, returned on the opposite side of the tank to the propeller. Between the engine and the tank two dynamometers were placed on the shaft—a direct thrust and a rotary one. Upon a rigidly fixed table, placed over these dynamometers, was attached a recording instrument specially designed by the head of the Department of Steam Engineering. From this simple and yet reliable installation the power developed in the cylinders and that exerted by the propeller could be compared. By noting the thrust upon both the rotary and the thrust dynamometers the power expended in frictional resistance could be ascertained, it being represented by the difference in the pressures recorded.

The scope of the experiments embraced the working of propellers of different designs, as regards pitch, area, shape and number of the blades. Thus it was possible to secure absolute comparative data as to the power required to operate the different propellers at varying speeds. It was also proposed to test the same propellers under different conditions of immersion—which would be from as deep an immersion as the tank would permit to a condition where the blades would be partly out of water.

When Professor Biles, the eminent British naval architect and marine engineer, visited the Academy in 1896, he expressed surprise and satisfaction at finding an installation whose cost was so slight and yet whose capabilities were so vast in securing reliable data upon this important subject.

The head of the Department of Steam Engineering at the Naval Academy at that time had practically but a few hundred dollars as a contingent fund, but with the aid of the machine-shop resources and the inventive genius of his staff of assistants, he showed the character of the original experiments that may be conducted when a well-established laboratory is in operation under intelligent and scientific supervision.

Many more illustrations could be given as to the manner in which important experiments have been discontinued from both necessary and unnecessary causes. It is methodical, thoughtful, and persistent work which counts, and as the German excels in this respect, the engineering world is now beginning to understand in its fullness the value of the work done at the German engineering laboratories in promoting German success in both naval construction and maritime development.

Germany Appreciative of Scientific Research.

It is an anomaly that the greatest of military nations should be the first to appreciate the scientific attainments and capabilities of the engineer, and it is for this reason that Germany has a start of at least five years over England, France, and America in systematic naval engineering research. In all probability each of the three other nations has spent more money than Germany in experimental work, but German expenditure, in great part, has taken place before the article is manufactured or the ship is laid down, while in the case of some rival powers, tests and experiments have been conducted to discover means of overcoming avoidable defects.

Research Should be Conducted for Preventing Rather than Remedying Evils.

The proverbs that "an ounce of prevention is worth a pound of cure" and that "a stitch in time saves nine" are as applicable to-day as they were in the last century. It is for this reason that the preparatory experimental work conducted by Germany has been productive of greater results than that done by rival powers working in the direction of seeking remedies for existing evils.

The cost to the British government of using the cruisers "Hyacinth," "Minerva," and "Hermes" for comparative boiler tests and experiments will approximate more than the cost of establishing and operating both the Charlottenburg and the Dresden stations since their inception. In our navy it had been suggested to effect a change from in-turning to out-turning propellers of all the battleships and large cruisers in course of construction, without even carrying on a system of comparative tests to find out whether or not the change is desirable. It is illustrations of this character that should cause experts to take an inventory of naval strength by conducting comparative experiments, and thus testing the endurance, efficiency, and fighting value of the expensive floating machines that are commonly termed battleships.

An Experimental Station of More Value than a Single Battleship.

If it be true that the battleship of one generation is the junkheap of the next, then an economical race like the German is pursuing a wise policy in conducting experimental research and investigation

in the direction of finding out how the weak links in the naval chain can be strengthened. In the race for naval supremacy it is bullion, as well as brains, that counts. As the financial budget of Germany may not be so satisfactory as that of England or America, it is imperative upon the part of the Admiralty in Berlin to take good care, even from a financial standpoint alone, that no mistakes shall be made in naval construction.

Experience has shown that the German engineering laboratories are more than a good paying investment, for there is not an expert in that empire familiar with the work being done at these laboratories who does not believe that their destruction would be a greater national calamity to the navy and the nation than the loss of one of the battleships of the home squadron. The warship could be replaced in four years. It would take six years to rebuild and put in effective operation the complete installation for conducting experimental research that has been developed and perfected at the Charlottenburg and Dresden technical colleges.

There is probably not an eminent naval or mechanical engineer in America or England who has given consideration to this question who is not also of the opinion that the establishment of a national experimental laboratory for naval purposes will vastly contribute to military strength. Probably the majority of these experts also believe that such an institution would eventually contribute more to actual naval strength than the building of a battleship. One does not need to possess vivid imagination to realize that much is contributed to the fighting strength of a navy by carrying on research along engineering lines, and thus preventing the design, construction, and installation of appliances that are ill suited for the purposes intended.

Special Engineering Features Projected.

In the preparation of the tentative plans for both the equipment and the operation of the laboratory, it has been deemed wise to thoroughly inquire as to what has already been done both at home and abroad. Through correspondence and official visits, the equipment of the leading American institutions has been inquired into. From diploma graduates, as well as from other sources, the Bureau has received valuable information as to the character of the research that is being conducted at the European technical colleges.

The Bureau is particularly indebted to President Henry S. Prit-

chett, of the Massachusetts Institute of Technology, for a copy of the report of Professor Edward F. Miller, of that institution. This technical expert of the faculty had been commissioned by the President and Corporation of the Institute to visit the most important technical schools of England, Germany, Switzerland, and France, in order to report upon their methods of technical instruction and upon the laboratory equipment.

Of late there has been a great scarcity of naval engineering experts available for detail to special duty, and as it was not compatible with public interests to assign an officer to visit the engineering institutions of Europe, the report of Professor Miller is exceedingly opportune. In some respects it covers the field of information desired by the Bureau as to the development of the purely engineering laboratory on the Continent.

In collaborating the information received from various sources, the Bureau is of the opinion that the laboratory at Annapolis should in many essential respects be patterned after the Charlottenburg school along steam and material-testing lines; after that of Dresden as respects gas-furnace installations and hydraulic appliances; and after the Swiss school at Zürich in the equipment of apparatus for testing that class of turbines which work under low heads.

As for the character of the laboratory building and its furnishing, the technical college at Liverpool should serve as a model, since the building of this institution is an ideal one in many respects, especially as regards light and ventilation.

As there is a growing tendency upon the part of all the technical laboratories, both at home and abroad, to encourage research work and to teach engineering methods and practices, there should be little time wasted, in encouraging either faculty or students received for instruction, in the effort to acquire manual skill in the operation of tools and appliances, since such work should be the sphere of the manual training school rather than that of a research laboratory.

The museum of the laboratory should contain applications of all the different mechanical movements; every form of quick-return motion; models of various systems of valve gear and linkages; special sets of Reuleaux models, elements of the principal forms of marine boilers, and various designs of steam turbines. In all probability the success of the steam turbine in the future will be a development of a combination of features of several designs rather than the improvement

of any one type, and, therefore, special prominence should be given to this subject.

As the success of the laboratory as a whole must be the primary aim, it should be the Director of the Experimental Station, working under the supervision of the Bureau Chiefs, and not the individual heads of special departments, who should determine the character of the work to be done at the laboratory. Probably the special weakness of the German laboratory organization rests in the fact that each particular branch of research work is under a separate head, where every professor in charge is absolutely supreme in his own department. As a consequence, that branch of the laboratory is most developed which has the ablest staff. Such an organization of faculty leads to jealousies among the members, and thus prevents the advancement of the general research work and scientific investigation.

Influence of the German Technical Laboratories.

While the experiments conducted at the Charlottenburg, Dresden, and Zürich laboratories relate chiefly to improvements in machine design and to the study of the practical application of the principles of kinematics, the work of these institutions has indirectly had a very important bearing upon matters relating to marine engineering. The primary purpose of these laboratories is to give students an opportunity to analyze and report upon the operations of various kinds of machines, pumps, compressors, motors, and engines. Experiments and tests are likewise conducted for cheapening the manufacture and improving the character of commercial appliances, particularly in the direction of manufacturing articles that will find a sale in foreign markets.

The more one studies the work done at the German technical laboratories, the more impressed he becomes with the thoroughness and patience that characterize such research. The attention to details, and the conscientious effort to secure absolute information and not to sustain theories, have proved a direct benefit to the extension of the German mercantile marine, by reason of the fact that many German naval architects and marine engineers have received training and instruction in these laboratories. Men who receive such training become imbued with the necessity and importance of carrying on comparative experiments in an intelligent, conscientious, and scientific manner.

Every national engineering laboratory should set the pace for technical experimental work, and, therefore, one does not need to possess gifts of prophecy to predict that the engineering laboratory at Annapolis will rapidly develop into an institution that will improve the character of our naval construction, if not advance the extension of our merchant marine.

For Years Our Need of such a Station has been Manifest to Naval Engineers.

In 1895 a bill was introduced in the Congress providing for the building and equipment of a naval engineering experimental laboratory at the New London Naval Station. There were many reasons for locating the experimental station in that vicinity, and this site is to-day the superior one in many respects. When there was a separate corps of naval engineers, however, there were special advantages in having an engineering laboratory located, like that of the War College, at a place entirely distinct from the Naval Academy. With the amalgamation of the duties of the line and engineer officers, Annapolis became the logical place for the establishment of the enterprize, although it is the most ill-suited of all locations if the Academic authorities do not welcome its coming.

For the past eight years, therefore, the Bureau of Steam Engineering of the Navy Department has had in contemplation the establishment of such an experimental plant. The scarcity of officers during the Spanish-American war, and for several years following that event, made it impracticable to urge the measure; but during the intervening time the Bureau of Steam Engineering has made persistent efforts to collect all possible information relating to the subject.

Co-operation of Bureau of Navigation Secured.

About three years ago the question was carefully considered by Admiral A. S. Crowninshield, and the Bureau of Navigation was induced to cheerfully co-operate in a renewed effort to have the station authorized by the Congress. Both Secretaries Long and Moody approved the proposition in its entirety. The measure only failed to become incorporated in a previous appropriation bill by reason of the fact that the amendment of the Senate, authorizing its establishment, was stricken out by the naval conferees, clearly upon a misunderstanding as to the purpose and necessity for such a laboratory in a modern navy.

It takes time, energy, and money to develop such an institution, and therefore the resulting benefits can only be observed after such a laboratory has been in operation for a considerable period. The advance of Germany in naval engineering research will be much more apparent during the next few years than it is now, and it was in recognition of this fact that the Fifty-seventh Congress was induced to authorize the building of such a laboratory for the American navy. It will be years, however, before the full value of the laboratory may be made manifest to the service at large.

Too Little Research along Naval Lines has been Conducted.

It can be absolutely stated that the navy is behind the times in original work and research. Several months ago one of the marine superintendents of one of the Great Lake transportation companies told me that if he were called upon to retrench in expenditures the last item to be cut down would be that for experimental purposes, since both the cost of construction and the expense of operation of the steamers under his control had been reduced as a result of the data secured from experimental work. There is not a leading university, large manufacturing concern, or great transportation company that does not consider it imperative to make tests and experiments. Every navy will also find that it will increase efficiency and promote economy to conduct and to encourage extended investigation of unsolved problems relating to its marine service.

Unless its industrial leaders have acquired a technical and scientific educational foundation, no nation can secure marked advance either in the field of manufactures or in naval construction. The welfare of the technical high schools and scientific laboratories is likewise dependent upon industrial prosperity, for in times of financial depression there is a tendency to minimize research and investigation. Now that there is a strong sentiment in favor of carrying on naval research, the work should be pushed so that results can be accomplished which would show its imperative necessity to naval development.

A few dollars spent in well-directed and conscientious experiments may result in the saving of hundreds of dollars elsewhere. The cost of maintaining a battleship in commission will approximate $1000 per day, and warships have been tied up for weeks on account of the corrosion of a few hundred dollars' worth of boiler tubes. It will repay the nation for the cost of an experimental station if the

staff of the laboratory will simply cause increased length of life of both boiler and condenser tubes.

Naval Engineering Problems to be Solved.

The field to be covered by experimental research along engineering lines is vast. The following are only a few of many urgent problems in the solution of which the navy has a direct interest:

1. The value of liquid fuel for various naval purposes.
2. The possibilities of the steam turbine for installation in warships.
3. The efficiency of various forms of propellers.
4. The relative advantages and disadvantages of in-turning and out-turning screws.
5. The reduction of vibration of machinery.
6. Limits of economical increase of steam pressure.
7. The development of practical appliances for utilizing the advantages of superheated steam.
8. A proper ratio of sizes of cylinders for multiple-expansion engines.
9. Improved systems of economy in auxiliary machinery of naval vessels.
10. The value of condensed fuel, such as briquettes, etc.
11. The relative advantages of straight and of bent-tube types of boilers for torpedo boats, gunboats, cruisers, and battleships.
12. The corrosion and deterioration of boiler and condenser tubes.
13. The relative value of various alloys for machinery purposes.
14. The types of valve gear most suitable for naval purposes.
15. The endurance of the storage battery and its possible development.
16. The more extensive use of steel castings.
17. The question of lubricants.
18. Calibration of gauges and of instruments necessary for naval engineering purposes.
19. The proportions of centrifugal fans.
20. The most effective systems of forced draft for various classes of warships.
21. Mechanical refrigeration, the present method of cooling magazines being far from satisfactory.
22. Testing non-conducting and fire-proofing materials.
23. The determination by actual test of the best proportions of important engine details.

24. The study of the problem of how to secure more complete and definite information upon trial trips.

25. Reliable form of water-glass gauge that will be applicable for forced-draft conditions as well as when muddy feed water is used.

Primary Object Desired by Establishment of Station—Increase of Naval Efficiency.

The primary reason and chief object for establishing the laboratory is to increase the efficiency of the naval service by preventing the adoption on our ships of war of untried or doubtful devices and expedients.

Since it is the aim of many promoters to force their wares upon the government, every executive department should have at its command a laboratory or a station where extended tests could be made for determining the value and usefulness of every appliance submitted for adoption.

A secondary, if not equally as important a reason for establishing the station at the Naval Academy, is due to the fact that such a laboratory could be utilized for the instruction of the midshipmen. The time has now come when the Naval Academy should be primarily an engineering school, and this should be evidenced by the extent of the installation and the facilities for conducting research, as well as by the character of the instruction imparted.

The experimental station would likewise be valuable for a proposed post-graduate course in engineering. This work is essential to naval efficiency, and is earnestly desired by many junior officers of the service. Post-graduate work in engineering has been recommended by the Academic Board, for this advanced work is absolutely necessary to secure the large complement of engineering experts that will be needed in the near future. If the laboratory will help to provide for this supply, its establishment will be alone justified by giving such experts to the navy.

This Laboratory was Established after Extended Investigation and Consideration.

The section of the naval appropriation bill relating to the establishment of the experimental laboratory was very carefully discussed in the House of Representatives. On a division, there were 72 votes cast against and 50 for the proposition to have this appropriation form part of the total sum allowed for the rehabilitation of the Naval

Academy. It is quite significant that there was practically no opposition manifested in either the House or the Senate to the commencement of this work, after the purpose of establishing such a laboratory had been understood.

Intent of the Congress as to the Purpose of the Station.

In order that the intent of the Congress may be clearly made known as to its idea of the scope and purpose of such a laboratory, the following statements of the members of the House Naval Committee are herewith repeated, the remarks having been made during the debate upon the naval bill:

Mr. Mudd, of Maryland, said: "The fact of it is, that this building is so far from being any essential part of the Naval Academy that at one time, the gentleman will recall, a proposition was made to insert the provision in the bill, making the appropriation and authorization, but left the location at the discretion of the Secretary of the Navy."

Mr. Butler, of Pennsylvania, said: "We considered in the Committee on Naval Affairs the importance of this building. It is a beginning; not of more building, but, in my judgment, the beginning of a policy under which the Navy Department will insist on requiring that all men entering the navy shall become proficient in the art of engineering."

Mr. Dayton, of West Virginia, said: "This is not a building for the training of midshipmen. It is a building and an institution for the purpose of experimenting and testing all the many questions that spring up in marine engineering. It may be utilized for advanced study in marine engineering, but if that course is to be given, it will be given to our officers after they have graduated from the Academy. This is simply in line with the school that has been established by the German nation, and which has been found to be of such great advantage to the German navy. In fact, I undertake to say that the German Empire would rather dispense with almost any other institution than its school of engineering at Charlottenburg. This, as I have said, has nothing to do with the Naval Academy. It has been located at Annapolis by the Committee for two reasons: First, because the government has the land there; second, in order that the midshipmen there may have the benefit of observing the experiments that may be carried on there. Attendance upon such experiments will not be made incumbent on the midshipmen. If any one is to be instructed there, it will be our engineer officers."

Mr. Tayler, of Ohio, said: "The Secretary of the Navy, who was for many years under the tutelage of the same Chairman of the Committee on Appropriations here, obtained and justified his reputation for economic administration of public affairs and the economic expenditure of public money, and I know that no public duty relating to the expenditure of money has lain with greater gravity upon his conscience and judgment than this question of the increase of the amount that should be available for this great improvement at Annapolis.

"Now, this matter for the testing laboratory is entirely independent of the Naval Academy, and was intended originally to be independent of it. So far as Admiral Melville was concerned, and so far as anybody else connected with the Navy Department was concerned, it was immaterial where it was to be put. In the first instance it was thought it was to be put at some other place, but in the later consideration of it we thought it had better be at Annapolis.

"The Secretary of the Navy insists upon the original plan as proposed. I do not mean the detailed plan, but the general plan of the Naval Academy, requiring the expenditure to be fixed at not less than $10,000,000. This is an entirely different proposition from this provision that we have now under consideration."

Mr. William W. Kitchin, of North Carolina, said: "If gentlemen will read the testimony of the Department they will believe this building ought to be erected. There may be some question as to whether it should be erected at a navy yard or the Academy, but there is no question that Congress ought to settle this matter if we are to have the building."

The project has also been carefully considered by the Senate Naval Committee when the naval appropriation bill of a previous year has been under discussion, the Senate having incorporated an amendment to the bill as it came from the House, making provision for the establishment of such a laboratory. Even up to the closing hours of the first session of the Fifty-seventh Congress the Senate conferees, Senators Hale, Perkins, and Tillman, had insisted that the Senate amendment relating to the establishment of a laboratory should prevail.

The Naval Academy will be a Large Beneficiary of the Project.

The above discussion conclusively shows that the primary purpose of establishing the experimental laboratory was for naval engineering

research, and not to form part of the integral course of the Academy training. It will be a valuable adjunct, however, to the educational work of the Naval Academy, and it may not be many years before it may indirectly have a very important influence upon the professional course of instruction.

In recommending that it be established at the Naval Academy, it was the purpose of the friends of the measure to extend the prestige and the influence of the Annapolis institution. There was no desire nor belief that it would in any manner infringe upon the prerogatives or conflict with any policy or official action of the Superintendent or the Academic Board. Its primary work and purpose, however, must be absolutely distinct from the undergraduate instruction of the Academy.

The Work is National in Character.

The Bureau of Steam Engineering has been constantly urged to carry on experimental work relating to naval engineering affairs. It can hardly be expected that the shipbuilders, the manufacturers, and the technological colleges should be subjected to the expense of conducting tests that are primarily for the benefit of the naval service, when such experiments promise to yield but little financial reward or professional prestige to individuals. It may also be the case that there are military reasons why this information should not be received through others. The expert talent to initiate and to conduct tests will always be available at Annapolis. The needs of the Naval Academy will always require a strong force of able and highly trained engineer officers, and the senior class might render valuable assistance at times in helping to collect data, for it is certain that some very efficient observers would always be available from those who had aptitude and natural talent for engineering work.

Indirect Advantages Accruing from its Establishment.

In measuring the benefits that will accrue to the navy and to the individual officers from the establishment of the station at Annapolis, the indirect advantages must also be taken into consideration. There is no doubt that the shipbuilding firms engaged in naval construction will seek information that could only be secured at such a laboratory. If such information will make the naval ships under construction more efficient and more enduring, the government can well afford to

furnish the data requested, even though the shipbuilders themselves may reap consequential benefits.

Such an institution will also bring the Naval Academy in closer touch with the technological schools of the country. It is certain that such friendly intercourse will not only materially strengthen the engineering curriculum at Annapolis, but create a greater interest among the universities concerning naval needs and development.

The influence of every university of higher education is most accurately gauged by its relative standing among other similar institutions. It is obvious also that the great universities are judged very much by the character and extent of the original and research work that they undertake. The Naval Academy, therefore, cannot help but be benefited by the proposed engineering-research laboratory. It is for this reason, likewise, that the academic course will be strengthened by being associated more or less with the work of a laboratory which aims to conduct such practical research that our naval engineering plans and specifications will stand as models of their kind.

The station ought also to prove a boon to young and zealous officers. Under existing conditions energetic and studious officers are often discouraged and repressed because there are neither facilities nor funds available to test the merits of plans and inventions submitted by them, and which are strictly naval in character. Surely the inventive genius and the professional aspirations of many officers would be encouraged and expanded by the work of such a laboratory. In the immediate future there ought to be a hundred officers stationed within a few hours' ride of Annapolis who would have a direct interest in some feature of the projected work, and many valuable suggestions would in turn come from such individuals. It has been a great detriment to naval efficiency that an engineering laboratory was not established years ago, for if it had been in operation, there would have been far greater advance in electrical, hydraulic, and mechanical engineering, particularly along naval lines.

Competent Engineer Officers can be Found in the Navy to Carry on this Work.

About twenty-five years ago the Congress of the United States passed a law empowering the President, upon the application of an established scientific school within the United States, to detail an officer from the engineer corps of the navy as professor of marine engineering and naval architecture at such an institution. As a result

of that act, technical education in the United States is greatly indebted to the navy, by virtue of the splendid work done by the two-score officers who were detailed to various scientific schools.

Some of these technical schools were practically organized by naval engineers, and no fewer than four of the leading universities now have as directors of their scientific colleges ex-engineer officers of the navy. These institutions are Harvard, Cornell, University of Pennsylvania, and Ann Arbor, and therefore cordial co-operation with these and other institutions is assured. The opportunity that these officers had of noting foreign industrial and educational methods fitted them admirably for this educational work, and there is no doubt but there are other officers in the navy who will rise to the responsibility of conducting the proposed experimental laboratory in a manner that will reflect credit upon themselves, the service, and the country.

The engineering world is very appreciative of the helpful influence exerted on technical education by engineer graduates of the Naval Academy, and as there are within the service many officers who, by training, education, and experience, ought to be qualified for conducting engineering research, there need be no fear that the work of the navy will not compare favorably in lines of engineering research with that of any other technological institution.

Important and Scientific Research Conducted at University of Glasgow.

It has been recognized in Great Britain that the reason for Glasgow being the metropolis in mechanical engineering has been due, in great part, to the scientific laboratory attached to its great University. Upon this subject "Engineering," of London, states:

"It was at this University that James Watt perfected the system of separate condensation without which the steam engine would have been a very expensive appliance. Watt likewise discovered in this laboratory the principle of latent heat, and laid the foundation of an inventive skill which brought forth the steam jacket and other improvements that caused the steam engine to produce power in a more economical manner. It was here that Professor Gordon worked out his formulæ in connection with the strength of columns. The work of the eminent scientists Rankine, James Thomson, and Lord Kelvin will ever be associated with the laboratory of this Scotch University."

In strongly urging an appeal for funds to extend the work of the laboratory at Glasgow, "Engineering" further asserted:

"There are many reasons why liberal response should be made, not only by the west of Scotland, but by many others further afield. We could name many instances of works in Britain where a want of knowledge in first principles has led to a great waste of money. The tendency of more class-room training may have the effect of overconfidence in estimating the power to withstand stress, while the practical training alone tends to the opposite extreme. The influence, therefore, of that quickening of observation and of that practical training in the properties of material to be accepted in a laboratory will go some way to insure greater economy.

"It must not, however, be understood that the laboratory can ever give the same training as the workshop. It will, however, prepare the way for that wider experience in the case of students who have not previously been through the mill of practical apprenticeship. It will supply the necessary link between their practical training and their studying of scientific principles and method. In this respect it is indispensable."

British Opinion Concerning the Value of Naval Research and Experiments.

It is because there is no better way of showing the value of such a laboratory for naval purposes than by collating the opinion of some representative engineering experts, that a few extracts from leading technical journals are also incorporated. The following editorial from the "Marine Engineer," of London, will show the trend of British engineering thought with regard to the question:

"It is well known that inventors receive little or no encouragement from the Admiralty, who generally require that an invention must have been thoroughly tested and proved by actual use elsewhere before they will practically consider its utility. This is quite understandable where they have no special staff and establishment where and by whom such proposed novelties could be tested and reported upon, even in their first embryo condition.

"It must be remembered that the present policy discourages the adaptation of inventions to the special needs of the fleet, or forces the more capable and enthusiastic inventors to go abroad or to the States for the development of their ideas as applied to naval subjects. Now, the German government is much more practical in this respect. There is a naval laboratory established at Charlottenburg, where all new proposals for the benefit of the German navy can be experimentally

tested and the probable advantages or otherwise reported upon, thus clearing the ground, if the report is favorable, for a more extended adaptation in practice.

"The Engineer-in-Chief of the United States navy is now agitating in his country for the establishment of a similar experimental department at the Naval Academy. What is wanted in the United States is equally required here.

"Such onus of recommendation, and a genuine desire to investigate, can only be expected from a staff which has nothing else to do, and which will only justify its existence as an experimental staff by finding and supporting novel inventions and improvements from time to time.

"Had such an experimental staff and laboratory existed when the adoption of water-tube boilers in the navy became a burning question, the naval engineers need not have been tied to the adoption only of such a type of boiler as had already a naval record. The whole question as to type for direct investigation could have been submitted to such a laboratory staff, as has been done later by a specially appointed boiler committee. Much valuable knowledge might thus have been gleaned as to various types of boilers available, irrespective of their naval record, before any considerable adaptations to cruisers had been effected. We do not think, under these circumstances, that the Belleville boiler would have been the type selected."

Views of Professor Peabody, of the Massachusetts Institute of Technology.

In commenting upon the proposed engineering laboratory, Professor Peabody, of the Massachusetts Institute of Technology, writes:

"The experimental station will have three objects in view:

"1. The training of midshipmen.

"2. The training of junior officers.

"3. The investigation of engineering problems.

"This order is not intended to represent the order of importance in my own mind; I am not sure that I should consider one more important than the others. To my mind the three should be confined in all the work of the station; thus the officers detailed for the purpose should arrange and oversee the experiments, the junior officers should be given responsible charge of individual investigations, and the midshipmen should work under instruction as observers and assistants. Of course, there will be divergence from any such a scheme, but I believe the idea is right."

There need be no apprehension that such a laboratory will turn out too many specialists. The future complaint will be that too few experts are trained. It can be anticipated that some officers who have pursued investigation and original research along special lines will receive inducement to resign their commissions, and thus in laying out the project those interested in the project should anticipate the wants of a future decade rather than the needs of the next few years.

Recent Engineering Extension at Leading Universities.

In connection with the demand for men with engineering training, the following extract from the March number of the "University of Michigan News Letter" will afford considerable information:

"The demand for engineers throughout America at the present time is far in excess of the supply. Even at this early date, four months before commencement day, many requests for engineers have been received by the heads of the engineering departments of the University of Michigan. Some of these requests have been so urgent as to ask that students be advised to postpone graduation in order that they might take up work at once.

"That this demand for engineers has been felt by other schools of the United States as well as by Michigan is most forcibly shown by some of the appropriations recently received for engineering buildings and equipments by various institutions.

"Not long ago Harvard spent $500,000 for engineering buildings; Wisconsin University recently received an appropriation of $200,000 for the same purpose; the Iowa Agricultural College has built a $200,000 engineering building; the University of Pennsylvania is just about to build a $300,000 engineering building; the University of Illinois has just asked its Legislature for an appropriation of $300,000 for the building of engineering and physical laboratories, and the University of Michigan is at present completing a building which, it is estimated, will cost $160,000."

The Stevens Institute of Technology has also received during the past year $225,000 as a special endowment for the support of the Carnegie Laboratory of Engineering.

Co-operation with the Carnegie Institution in Washington should be Effected.

In giving $10,000,000 as an endowment fund for an institution which would encourage individual work in scientific investigation, it was

undoubtedly the purpose of Mr. Carnegie to include in the purposes of this gift the promotion of experimental research along maritime and engineering lines. It can certainly be expected that when the Annapolis institution is in operation, the trustees of the Carnegie fund will find it compatible with the purpose of the donor to encourage civilians, if not individual naval officers, to work in conjunction with the staff of the engineering laboratory at Annapolis.

Now that every nation looks upon the ocean greyhounds as possible scouts in time of war, the mercantile marine has become an important military auxiliary. In the operation of a fleet of battleships it is essential that there should be repair, supply, and refrigerating ships, as well as colliers and transports, and, therefore, the logical place for naval architects and marine engineers to work out special problems in connection with the increased efficiency of naval auxiliaries would be at the Annapolis laboratory.

There would be mutual benefits accruing to the naval service and to individual experts if beneficiaries of the Carnegie fund should be permitted to pursue their investigation at the naval engineering laboratory. The individuals would be benefited by reason of the fact that it would not be necessary for them to expend funds for the purchase of instruments of precision that were at the Annapolis institution, and they would also be able to secure conscientious and intelligent observers free of cost. The naval service would derive a benefit by noting the trend of research upon the part of the experts in civil life.

This government laboratory ought therefore to be open to civilians as well as to officers, especially where the resulting investigations would be conducted at slight cost to the government.

As it was the particular desire of Mr. Carnegie that the work of others should not be duplicated, and, as the Congress established the Annapolis school for original research, the purpose of both would be well subserved in having the naval engineering laboratory cordially welcome investigators who were conducting research that related to improved economy and efficiency in transportation and in maritime matters, for rapidity of movement of both men and supplies in time of war now constitute an important military factor.

Modern Industrial Conditions Require Large Corporations to Maintain Mechanical Laboratories.

All of the large industrial and transportation corporations maintain complete testing departments or bureaus of tests, presided over by

experts of national reputation who have under them an ample corps of assistants. The work done at these laboratories in advancing and improving the character of railway and manufacturing appliances and in certifying to qualities of purchases has been of great financial gain to the several corporate interests.

If a private corporation finds it essential to maintain such a testing plant, how much more should the navy—a corporation of far greater size—find the maintenance of such a station profitable for the direct return secured, but likewise necessary for preventing retrogression!

Improvement in Engineering Efficiency of the Enlisted Personnel.

Vessels assigned as training or instruction ships for stokers, machinists, etc., might occasionally rendezvous at Annapolis, in order to assist in particular experiments and to keep in touch with the engineering officers and work of the projected laboratory. Such experiments ought to arouse in the men a greater interest and incentive in naval work, for all would then see and know that the best of apparatus and methods are thoroughly tested before being installed afloat. For an enlisted man to have firm confidence in his ship's armament and motive power is a great gain. Should the "man behind the gun" not have confidence in his weapon, the battle is partly lost. Equally as well, the fireman who faces the furnace must have confidence in the safety and endurance of his boilers, otherwise he will likely fail in doing his full duty in times of emergency.

On board, every one of the assigned for the training of the enlisted force of the engine and fire rooms would be warrant machinists and stokers who were desirous of advancing, and who would, therefore, be receptive of information. Among this class would be found many chief machinists, water tenders, and oilers whose services could be utilized for special work. These men would regard it as a post of honor as well as a responsibility to be given such assignments. As such elections would naturally be made from those whose signal ability had indicated to the commanding officers that the naval service would gain by their temporary detail for such work, it would be possible to secure valuable observers from this force.

The possibility of being called upon to take part in valuable experiments would act as a spur to the ambition of the enlisted force. It would be viewed by them as an opportunity to fit themselves for higher work. It would also be regarded as a privilege to be intrusted

with the responsibility of helping commissioned officers carry on tests that were asked for by the engineering world.

It would add to the military *esprit de corps* of the engine-room force to be thus designated for work in the naval-military atmosphere of the Academy. Every man on a fighting ship is a combatant, and he should be shown the power and force of the weapons intrusted to his charge.

The Projected Laboratory will not Duplicate the Work of the Naval Academy nor that of any Technological College.

It should be distinctly understood that the projected laboratory at Annapolis will not in any respect duplicate any of the work done at the Naval Academy. In its scope and purpose it will also be quite distinct from that of any other institution in the United States. The development of the engineering laboratories at Harvard, Yale, Cornell, Ann Arbor, University of Pennsylvania, Massachusetts Institute of Technology, and similar institutions is primarily along the line of physical, chemical, and technical research. The main purpose of the Annapolis plant will be in the direction of naval engineering development. It is also proposed to conduct special technical investigations which the officers attached to the various naval stations and ships have neither time nor opportunity to undertake.

As it can be expected that the Congress will make liberal annual appropriations for the support and operation of the engineering laboratory, and as there may be occasions when war vessels may be ordered to Annapolis in connection with particular experiments, it ought not to be possible for any other mechanical laboratory in the country to compete with the naval institution in conducting experiments of a strictly marine character.

While Experiments are Costly, the Information Secured will be Extremely Valuable.

Some of the experiments will be quite costly, but when the fact is recalled that six boiler firms in Europe and America during the past ten years have expended one-half million dollars in tests and experiments upon marine steam generators, the necessity for naval investigation upon all subjects pertaining to the motive power of warships becomes very apparent. A minimum appropriation of $50,000 should be asked for the first year of the station's existence, and this fact ought to be confirmatory evidence as to the necessity of having the

work of the laboratory distinct from the Academy course of instruction.

There would certainly be discrediting of engineering work if it were attempted to have the director of the laboratory, or any of his executive staff, assigned to any other academic duty. It would prove extremely advantageous, however, for some officers connected with the Academy to be detailed for temporary duty or instruction for short periods during special experiments, for such assignments would really be in the nature of post-graduate work. The Bureau regrets exceedingly that the present exigencies of the service now prevent the immediate nomination of an officer for special duty in connection with the work.

It is hoped that within a few months an officer particularly well qualified for laying out the plant may be recommended for this special duty. It will not only be discrediting the work of the laboratory, but will impair engineering education at the Academy, to expect any individual officer to carry on systematic original research in addition to other regular duty. The officer who is called upon to lay out the installation may set the pace of the work for the next ten years. This preparatory work is likely to demand the services of a number of officers rather than of one; so that there will be plenty to do in connection with the work for any one man from this time forward.

It is the Duty of All Officers to Assist in the Successful Development of the Enterprise.

The debate in the Congress undoubtedly shows that much is expected from this engineering station. It would only arouse resentment of influential personages if any action should be taken which could be construed as discriminating against such research. It has necessitated a campaign of education to secure the establishment of the station, and it will succeed if there is detailed an adequate and efficient complement of officers for duty in connection with the proposed experimental work.

This engineering laboratory will not encroach upon excellent work done elsewhere, and thus the directors of engineering research at the leading technological universities cordially approve the establishment of the government plant. Of necessity, the work done at the several educational universities must be pre-eminently in the more general line of physical investigation, while the research at Annapolis will be primarily in the direction of advancing naval engineering efficiency and endurance, and thus co-operation ought to be secured.

All Bureaus of the Navy Department Will Find the Station of Value for Research.

Since the station will conduct engineering research that will add to the general fighting efficiency of the ship, it will be but a few years before it will be as valuable an auxiliary to the chiefs of Bureaus of Ordnance, Equipment, and Construction as it is to steam engineering. There is no doubt but that in the early future the ordnance demands of the navy will compel the transfer of the experimental basin at the Washington gun foundry to Annapolis, as an adjunct to the projected laboratory. The work of the engineering laboratory will be of such broad character that it will not be conducive to naval efficiency and economy to maintain independently an expensive experimental basin that is limited in its scope. It is important to determine the best form of hull. It is of far greater moment to extend the broader project of a naval engineering laboratory, whose scope and purpose comprehend not only improvement in the design of hull, of machinery, and of auxiliaries, but also of the gun and its mount, as well as in armor and its attachment; in other words, the experimental engineering project makes for increase of efficiency and endurance throughout the ship.

Value of a Centralized Naval-research Laboratory.

This centralization of experimental work along naval lines has appealed so strongly to British naval experts that in commenting upon the proposed station at Annapolis, "The Engineer," of London, has editorially stated:

"When we say that what he (the Engineer-in-Chief of the United States Navy) wants—and what the British navy wants—is not a laboratory full of apparatus and students and experts, but an experimental board, or bureau, or committee—the name matters nothing—to carry out inquiries. The laboratory, properly so called, would be then little more than a species of head office or center from which the operations of the committee could radiate.

"We are fully persuaded that something like the amount, $400,000 (asked for by the Bureau of Steam Engineering), could be spent every year for several years to come by the engineer branch of the British navy, and that with the utmost benefit. We spend large sums now. The trials of the "Minerva" and "Hyacinth" were not carried out for nothing. The investigation of the strength of the hulls of torpedo destroyers will be costly. Various inquiries of the kind could be

mentioned. These are all good in their way; but their value would be augmented and their cost reduced if there was some specially constituted body to organize investigations and carry out experiments in a systematic and orderly fashion. . . . Is it too much to hope that Great Britain may do still better, and that a Board of Experiment will yet form a constituent department of the Admiralty?"

The British Admiralty Likely to Install a Laboratory of a Size Commensurate with its Needs.

The above declaration is very significant, particularly in view of the fact that the British Admiralty is about to follow our action in this respect. The new British Admiralty scheme of training officers for the royal navy is a development of our naval personnel law. It is probably an improvement, because it not only demands a longer time for training and a younger age for entry into the service, but because it also provides for compulsory duty in the engine-room.

From authoritative sources I have learned that the naval engineering laboratory project has appealed very strongly to many experts in the British navy, and that the principal fault found with the American installation is that it is proposed to establish it on too small a scale. The fact that British experts suggest an annual expenditure about equal to that requested for the installation and equipment of our plant is conclusive evidence that, as their demands are greater, they mean to surpass us in the character of the equipment of their laboratory for naval research.

It should be stated that in asking for $400,000 for buildings and equipment, I only requested an amount sufficient to show the imperative necessity of such a station, and it is my belief that the results accomplished will soon cause the Congress to grant liberal appropriations for the extension of the work.

The Element of Time of Extreme Importance in Getting the Project under Way.

There is no reason why actual work should not commence on the laboratory building before the end of the year. As there is an urgent necessity for the commencement of experimental research along naval engineering lines, the work of establishing the plant should be pushed with vigor independent of all other extensions and improvements projected at the Naval Academy. Any unnecessary delay in preparing

plans, advertising for bids, awarding contracts, or in actually commencing work will invite bitter criticism and official complaint.

While the authorization for this work is absolutely independent of the rehabilitation of the Academy, there is no reason why it should not supplement many features of the Academy. While the Bureau is specially desirous that the architecture of the laboratory shall conform to that of the other buildings projected at Annapolis, it will likewise take special care that its construction shall not be delayed by work upon other structures, since the project is absolutely independent of the rehabilitation of the Academy. The purpose of establishing this laboratory is as important as any special feature of the work connected with the rehabilitation of the Naval Academy, and therefore there should be no necessity for either work to interfere with that of the other.

The Value to the Industrial World of Experiments and of Tests Conducted under National Auspices by Disinterested Experts.

While important and far-reaching experiments have been conducted at the mechanical laboratories of the leading technological universities, the scientific and industrial world has been too well aware of the fact that the fund available by the educational institutions for engineering experiments has been but a small percentage of that allowed for physical research. Then, again, it has sometimes been believed that some of the individual experimenters have had preconceived opinions upon certain questions, and that only sufficient tests were conducted by them to sustain their particular contentions.

In fact, it has now become so easy to secure individual expert support to all phases of technical controversies that a great jurist recently asserted that he had about come to the conclusion that the character of expert evidence submitted is often in harmony with the views of the person who can pay the highest fee demanded.

When tests are conducted, however, under government auspices it has been a general rule to permit all directly interested in the experiments to examine records, and even to make copies of all documents that are not of a military nature. The professional reputation and even the commissions, as well as the prestige of the government experts, are thus at stake, and must act as deterrents to careless or ill-considered reports concerning experimental research.

The results of many of the engineering tests upon special subjects conducted under the auspices of the Bureau of Steam Engineering

have stood and will remain as standards in engineering literature. One has only to remind the technical world of the fact that it was a board of naval engineers which practically secured the adoption of an American standard of screw threads. It was naval experimental research which gave the world the navy-bronze, which is to-day the best all-around alloy for machinery work. It was naval investigation which caused the standardization of indicators and steam gauges. It was naval research that first impressed the industrial world with the possible economies that could be secured by utilizing to a greater extent the expansions from high pressures, as well as by super-heating the steam.

The notable series of experiments that have been conducted during the past two years by a board of naval experts, in securing comparative data as to the relative efficiencies of various coals and oils as combustibles, will be of incalculable benefit to the maritime and to the manufacturing world.

In general, naval engineering experiments that have been of an extended nature stand to-day unimpeached, practically standard in value, and regarded by the industrial world as data collaborated by capable experts of integrity and ability. With a well-equipped plant, and with liberal annual appropriations by the Congress, it can be expected that such a laboratory will not only prove a valuable military adjunct, but that Annapolis will become a center of engineering research for the mechanical world.

It was simply because the country at large did not possess a national university of research that Mr. Carnegie was induced to munificently establish an institution which would cover a field that had never before been occupied. If original investigation and research are worthy of the bounty of a private individual, surely a laboratory that makes for research that will increase naval efficiency is entitled to departmental encouragement and approval, as well as Congressional support.

Engineering Sentiment and Influence can be Depended upon to Support this Laboratory.

It is said that sentiment rules the world, and one cannot read the Congressional debates upon the proposition to establish this laboratory without fully appreciating the fact that regard and sympathy for things engineering was a considerable factor in securing the funds requisite for the building and the equipment of the plant.

The sentiment in behalf of the force working beneath the protective

deck of our warships is very deep seated. It not only exists in Congressional and in journalistic circles, but is implanted in the hearts of a large majority of the people at large. There is, therefore, in the word "engineering" a power and force that may be very momentous for good or for evil to the executive branch of the service.

The Academic board at the Naval Academy has only to give moral encouragement as well as cordial and official recognition to the purpose and work of this station to secure the gratitude and support of the engineering fraternity of the country. This may mean much for the naval service in the future. By reason of the present industrial prosperity of the country the appropriations for the support of the naval establishment are now given very cheerfully; but the time may not be far distant when there will have to be retrenchment, and the friends of engineering at that time will be found no small factor either in numbers or in influence in preventing the navy from being crippled.

It is certain that the standard which the navy at large places upon enigneering work will be evidenced by the interest taken in this project by officers stationed at Annapolis. Surely the line of the navy will not make foes of those who desire to be its friends, and therefore the establishment of the laboratory should be regarded as an important project—in fact, a means of putting into practical effect the spirit and purpose of the personnel law.

While it is true that the amount authorized for construction and for equipment of the laboratory is but 4 per cent. of the appropriation made for the rehabilitation of the Academy, it is equally true that there are members of both the House and the Senate Naval Committees who believe that the results secured from the naval engineering plant will surprise the service at large. The project has too many powerful friends not to succeed. It can be made a tower of strength to the line of the navy if it is given the same support and encouragement that have been accorded the Torpedo School and the Naval War College.

DISCUSSION.

The President.—We are indebted to Admiral Melville for the very full presentation he has given us of this subject. It is full of interest not only to officers of the navy, but to the mechanical and electrical engineers of the country as well, and I am sure Admiral Melville will be glad to have his paper discussed.

L. Y. Schermerhorn.—To what extent, at the present time, does the navy undertake to furnish the detailed specifications upon which our battleships are built? Are not these details decided by individual builders?

Rear-Admiral Melville.—As the discussion of a paper often brings out the most salient features of the author's contribution, I shall be exceedingly gratified to have the address severely and critically analyzed. Such a discussion would show the friends of the measure the difficulties that would likely be encountered in conducting original research and investigation. It would also show the scope and character of the work that is being done at the laboratories of the technological colleges and by leading manufacturers, and thus would prevent the naval authorities from duplicating work that is being done elsewhere.

In answer to Mr. Schermerhorn, I would state that before ship-builders are invited to bid upon the hull and machinery of any war vessel, the general plans of the entire ship have been worked out at the Navy Department. The administrative heads of the four technical Bureaus of the Navy Department form what is known as the Board on Construction. These administrative experts are the Chiefs of Bureaus of Ordnance, Equipment, Construction, and Steam Engineering.

In settling upon the general plans of a warship each of the bureau chiefs naturally guards the interests of his own department. The Board on Construction sometimes requires months in settling upon general plans, and when bids are sought for the construction of the ship, each bureau chief thoroughly understands the weight and space which will be allowed for the installation of the appliances under the cognizance of his bureau.

Practically every detail of a battleship is given to the shipbuilder before he signs a contract for the construction of the vessel. The specifications for the steam machinery alone will probably cover 150 pages octavo of printed text. It would be very remarkable if the Navy Department should depend upon the contractors for the working out of details. You must remember that there are not only in the several designing rooms of the various bureaus naval experts, but that the department has experts on the various ships in commission who can be called upon for information. The log books and special reports submitted at periodic times also afford valuable information. There is a Board of Inspection which conducts official trials, and which makes special visits to ships in commission. The various bureaus also keep in touch with officials abroad, and there are experts on all the ships in commission who are on the alert for everything new. The Navy Department has, therefore, facilities for obtaining information concerning foreign warships that could not possibly be secured by any individual shipbuilder.

The fact that the contractors accept the general plans and specifications prepared by the department conclusively shows that the shipbuilders understand that the details have been worked out by the naval experts.

In order to get the best possible warships, some naval officials believed that it was advisable to ask for second-class bids—that is, bids upon general plans and specifications prepared by the contractors. The fact that such practice has been abandoned is conclusive evidence that such policy did not make for naval efficiency. It is not necessary to go into details as to the reasons for discontinuing such practice, but in general it may be said that whenever the Navy Department accepted a substitute plan for its own, the navy secured an unsatisfactory ship.

The boilers of a modern armored cruiser will probably cost $300,000, and

there is not a shipbuilder who could not save 30 per cent. of this amount if he were permitted to install a boiler that would simply have capacity and endurance enough to carry the ship through the speed trial and for six months' cruising. The Navy Department, however, expects its warships to be efficient for years and not for months, and therefore we are permitting neither cheap nor tender boilers to be installed.

You all know that there is a great difference in the character and design of the auxiliaries, and that unless the department exacted high requirements we should have installed auxiliary appliances that would have to be renewed within a year from the time the vessel had her official trial.

The requests that have been made of the Bureau of Steam Engineering for changes in detail would surprise the engineering fraternity. Requests have been made that alloys containing a large amount of lead should be used for the main bearing brasses. We have been asked to cut up a shaft and fit it with couplings so that the original cost of manufacture could be reduced. Demand has been made to substitute cast- and wrought-iron columns for steel castings for engine frames. All this is an outcome of inviting second-class bids and of giving the shipbuilders any encouragement to the belief that the working out of details should be entrusted to them.

The President.—I think it may be said that the keynote has been struck in emphasizing the importance of this work to the navy. There is one thing more that might be said, and that is that battleships and armored cruisers are built for government use only, and for the defense of the country, and although the latter are modeled after our Atlantic liners in some particulars, there are principles involved in their construction that require special research in the line of experiments. We have only just had an illustration of this in the battleship "Maine," which has been sent to a navy yard, for looking over. This costly vessel, although constructed in the very best manner possible and after the most carefully considered plans, developed in a short time structural weaknesses which could not be foreseen by the designers and builders, and which might, it is fair to assume, have been avoided if the physical laboratory, which Admiral Melville advocates in connection with the Naval Academy at Annapolis, had been founded a few years ago.

It would certainly mark an advance in naval engineering should this country provide the means for founding and developing such a technical school. Such a work should not be left to individuals and corporations engaged in shipbuilding, because the building of battleships and armored cruisers is a specialty. They are built upon government plans, and it is only reasonable that the navy should bear the expense of the research and experiments necessary to perfect them. Furthermore, as has been said, it requires the expenditure of a large sum of money—more than private industries can afford to devote to it—to carry on such work. The appropriation of four hundred thousand dollars asked for will build a technical laboratory and start the work, but it will not equal what has been done by the German government at Charlottenburg.

We are indebted to Admiral Melville not only for his interesting paper, but for his presentation of it to The Engineers' Club of Philadelphia.

Rear-Admiral Melville.—In reference to the ultimate size and character of the projected laboratory, I would state that those who have carefully in-

vestigated the subject fully realize that the $400,000 appropriated for building and equipment is but the beginning of the work.

The majority of both the House and Senate Naval Committees were undoubtedly in favor of giving us a larger appropriation for the establishment of the laboratory, but as there were some members of the House Committee who did not believe in experimental work, it was deemed advisable to ask for a moderate appropriation. The discussion in the House, however, clearly showed that the friends of the measure did not consider that the sum appropriated would meet future requirements, and that the amount appropriated was for the starting of the work.

Experimental work cannot be done cheaply. One boiler firm alone in this country has spent $90,000 during the past two years to prove the good qualities of the boiler which it has designed for marine purposes. Probably a half million dollars has been spent by the builders of marine boilers in Europe and America during the past five years in experimental work. One firm in this country is reputed to have spent during the past six years over a quarter of a million dollars in experimenting with the steam turbine. There should, therefore, be spent at least a million dollars in connection with the proposed laboratory during the next five years in buildings, equipment, and cost of experiments, for there are many unsolved problems in marine engineering construction that the nation, and not the individual, should give consideration to.

Eugene M. Nichols.—I would like to ask Admiral Melville, if betraying no confidence, whether he could tell us anything in regard to the recent so-called trouble with the battleship "Maine." We do not expect it, but would be very glad if he could give us some information.

Rear-Admiral Melville.—That is rather a delicate subject, particularly as the ship was built in the city of Philadelphia. [Laughter.] A Board of Officers is now on board the "Maine," and until that Board submits its report it would be rather inappropriate for me to attempt to anticipate their judgment.

Henry G. Morris.—I propose a vote of thanks to Admiral Melville for the presentation of his very interesting paper. [The motion was put and carried unanimously.]

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, April 4, 1903.—The President in the chair. Eighty members and visitors present.

Sections 4 and 5, Article IV, of the By-Laws, were finally amended to read as follows:

"Sec. 4. . . . He shall perform such other duties pertaining to his office as may be imposed upon him by the Club or by the Board of Directors, and shall receive a salary to be fixed annually by the Board of Directors at its February meeting.

"Sec. 5. . . . He shall receive a salary to be fixed annually by the Board of Directors at its February meeting."

Mr. L. Y. Schermerhorn read a paper upon "Obstruction of the Navigation of Southern Rivers by the Growth of the Water Hyacinth."

Dr. E. K. Landis read a paper upon "Richards Prismatic Stadia Used as a Range-finder."

Business Meeting, April 18, 1903.—Postponed.

Business Meeting, May 2, 1903.—The President in the chair. One hundred and thirty members and visitors present.

Rear-Admiral George W. Melville read a paper upon "The Military Importance of Naval Engineering Experiments," and detailed the scope and purpose of the Naval Engineering Laboratory to be established at Annapolis.

The Tellers reported the election of Messrs. Wm. B. Cavin, David S. Creswell, Robert S. Scott, C. W. Thorn, and A. C. Wood to active membership; Messrs. H. G. Perring, Wm. H. Taylor, Jr., and D. Robert Yarnall to junior membership, and Mr. S. Jones Philips to associate membership; and that the proposed amendment to the By-Laws in order to have the salaries of the Secretary and Treasurer fixed at a definite time was adopted.

Regular Meeting, May 16, 1903.—Vice-President Comfort in the chair. Sixty-eight members and visitors present.

Mr. A. L. Baldwin (visitor) read a paper upon "Recent Rapid Base Line Measures, Precise Leveling and Triangulation."

Business Meeting, June 6, 1903.—The President in the chair. Seventy-two members and visitors present.

The Nominating Committee selected by the Board of Directors was announced as follows: James Christie, Chairman; W. P. Dallett, Charles Hewitt, L. Y. Schermerhorn, and Edwin F. Smith.

Mr. Henry G. Morris read a paper upon "A Consideration of the Gaseous Fuel Problem."

The Tellers reported the election of Messrs. F. T. Chambers, Charles C. Davis, Henry Hess, E. G. Marble, August A. Miller, Jno. W. Pollock, Peter Mullen, and Lewis M. Pyle to active membership, and F. K. Worley to associate membership.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

Postponed Meeting, April 27, 1903.—Present: The President, Vice-President Foster, Directors McBride, Riegner, Bonner, and the Treasurer and Secretary.

The Treasurer's report showed:

Balance, February 28, 1903,	$2602.35
March receipts,	535.00
	$3137.35
March disbursements,	1078.04
Balance, March 31, 1903,	$2059.31

Regular Meeting, May 16, 1903.—Present: The President, Vice-President Comfort, Directors Riegner, McBride, Bonner, Hegarty, and the Treasurer and Secretary.

The Treasurer's report showed:

Balance, March 31st,	$2059.31
April receipts,	432.31
	$2491.62
April disbursements,	670.78
Balance, April 30th,	$1820.84

The personnel of the Nominating Committee was selected as follows: James Christie, Chairman; L. Y. Schermerhorn, W. P. Dallett, Charles Hewitt, Edwin F. Smith.

On motion the June meeting of the Board was called for Monday, June 8th.

Special Meeting, June 8, 1903.—Present: The President, Vice-Presidents Comfort and Foster, Directors McBride, Myers, Bonner, Leiper, and the Secretary.

The Treasurer's report showed:

Balance, April 30th,	$1820.84
May receipts,	415.00
	$2235.84
May disbursements,	244.49
Balance,	$1991.35

Communications were read from nine engineering clubs and societies in reply to the request for an exchange of club-house privileges.

ADDITIONS TO GENERAL LIBRARY.

FROM NOVA SCOTIAN INSTITUTE OF SCIENCE, HALIFAX, N. S.

Vol. X, Part 4, Proceedings and Transactions.

FROM JAMES CHRISTIE, PENCOYD, PA.

The Metric System, F. A. Halsey.

Report of Committee Appointed to Discuss the Arguments in Favor of and against the Metric System.

FROM BOARD OF PARK COMMISSIONERS, WILMINGTON, DEL.

Annual Report, 1902.

FROM PENNSYLVANIA STEEL COMPANY, STEELTON, PA.

"From Steelton to Mandalay."

FROM METROPOLITAN WATER AND SEWERAGE BOARD, BOSTON.

Second Annual Report, 1903.

FROM JOSIAH MARVEL, WILMINGTON, DEL.

"Delaware Corporations," 1902.

FROM SEWERAGE AND WATER BOARD, NEW ORLEANS, LA

Report on Water and Sewerage, New Orleans, 1903.

FROM CITY ENGINEER, LAWRENCE, MASS.

Annual Reports, 1900, 1901.

THE ENGINEERS' CLUB OF PHILADELPHIA

1122 Girard Street

OFFICERS FOR 1903

President

EDWIN F. SMITH

Vice-Presidents

Term Expires January, 1904

SILAS G. COMFORT

Term Expires January, 1905

HORATIO A. FOSTER

Directors

Term Expires January, 1904

THOS. C. McBRIDE

W. B. RIEGNER

H. K. MYERS

Term Expires January, 1905

JAMES B. BONNER

GEO. NEVILLE LEIPER

D. A. HEGARTY

Secretary

J. O. CLARKE

Treasurer

GEORGE T. GWILLIAM

STANDING COMMITTEES OF BOARD OF DIRECTORS

Finance—Horatio A. Foster, H. K. Myers, W. B. Riegner.
Membership—W. B. Riegner, James B. Bonner, Horatio A. Foster.
Publication—Silas G. Comfort, James B. Bonner, D. A. Hegarty.
Library—Geo. Neville Leiper, Silas G. Comfort, H. K. Myers.
Information—Thos. C. McBride, D. A. Hegarty, Geo. Neville Leiper.
House—H. K. Myers, D. A. Hegarty, Thos. C. McBride.

COMMITTEES OF THE CLUB

Relations of the Engineering Profession to the Public—John Birkinbine, *Chairman.*

MEETINGS

Annual Meeting—3d Saturday of January, at 8 P.M.

Stated Meetings—1st and 3d Saturdays of each month, at 8 P.M., except between the fourteenth days of June and September.

Business Meetings—When required by the Constitution or By-Laws, when ordered by the President or the Board of Directors, or on the written request of five Active Members of the Club.

The Board of Directors meets at 4 P.M. on the 3d Saturday of each month, except July and August.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XX. OCTOBER, 1903. No. 4

RECENT RAPID BASE-LINE MEASURES, PRECISE LEVELING, AND TRIANGULATION.

A. L. BALDWIN.

Read May 16, 1903.

MR. ENLOE, an ex-member of Congress from Tennessee, once declared on the floor of the House of Representatives, that the Coast and Geodetic Survey was engaged in accurately determining the diameter of the earth, and that every time it added an inch to that accuracy, it cost a million dollars. I hope I may to-night give a good account of the annual appropriation of $25,000 which is allotted to the geodetic work of the Survey.

The greater portion of this amount is at present being used for the measurement, by means of a triangulation, of the arc of the ninety-eighth meridian. This triangulation, when completed, will stretch from the Canadian border on the north, through North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Indian Territory, and Texas, to the Rio Grande. It will, together with the transcontinental triangulation along the thirty-ninth parallel, each bisecting the country, form the framework or control for all surveys in the United States, and may be called the Supreme Court for all other surveys.

The Base-line Measure.

For controlling the lengths on the greater portion of this ninety-eighth meridian triangulation, the nine primary bases * were measured during the latter half of 1900. With this base-measuring campaign began the application of engineering economics to geodetic surveying. The continuation of this endeavor to secure, with the minimum expenditure of time and money, just the required accuracy, developed the remarkable record of the past season, when a double party completed four hundred and fifty miles of this meridian triangulation in less than eight months, and with only fourteen men employed.

Of these nine bases the Page Base is almost within sight of the Dakota line, and the Alice Base is in southern Texas, within 120 miles of the Rio Grande. These bases, together with the Salina Base on the transcontinental triangulation, will control the lengths of 1100 miles of this ninety-eighth meridian.

The plans for this base-measuring party, as well as for the triangulation parties which followed, are due to Mr. John F. Hayford, Inspector of Geodetic Work, Coast and Geodetic Survey.

The usual practice in regard to primary base measures has been to measure one base at a time when the necessity for it became apparent, and, as is the tendency with scientists, measure it with such an apparatus and such an accuracy as would add most to exact knowledge and without much regard to the energy necessary for it. The measurement of such a base, with the necessary preparation and standardization, frequently occupied a party for a whole season. The announcement that it was proposed to measure bases on the wholesale plan was the cause of many significant remarks by the older scientists in the Survey.

The general experience of the last half century in geodetic operations indicates that while the length of the bases may be measured with great accuracy, this high degree of precision is soon lost on account of the errors of the angle measurements.

The base net is the group of triangles immediately about the base-line, and by means of which the comparatively short length of the base is brought up to the average length of the lines of the triangulation. The loss of accuracy is most rapid in the base net where the

* A full account of the measurement of these bases may be found in Appendix No. 3, U. S. Coast and Geodetic Survey Report for 1901.

geometric conditions are less favorable than in the remaining portions of the triangulation. This experience may be illustrated by reference to the great chain of triangulation along the thirty-ninth parallel, where, on eight of the ten bases which control the entire length, there is no probable error greater than one part in 710,000. And yet the loss of accuracy is so great in the triangulation that there is no interval between bases on which the lengths are not at some point subject to probable errors as great as one part in 220,000, and there are several regions in which these errors exceed one part in 100,000. From this experience it was at once apparent that the bases should be at relatively short intervals and should have only such accuracy as would be commensurate with the angle measures. The intervals between bases on this thirty-ninth parallel triangulation were on an average 250 miles. Along the ninety-eighth meridian the average interval between bases was made short—a little more than 100 miles.

The instructions issued to my party stated the limits on each part of the work which would be necessary to keep within the degree of accuracy indicated by a probable error of one part in 500,000, and experimenting to secure a higher degree of accuracy was prohibited. A party consisting of eleven persons was organized, three of us experienced and two inexperienced officers of the regular staff of the Survey, one recorder, and five laborers. We arrived at the site of the first base, Shelton, Nebraska, on July 16, 1900, where no preparation had been made. During the next thirty-one days a field comparator was built, all the apparatus was standardized upon it, the Shelton Base, 7.9 kilometers in length, was measured, and the party traveled to the next base. One of the experienced officers then returned to the office, and the size of the party was reduced permanently to ten persons. On January 18, 1901, the departure of the party from the last base began, having in the six months standardized all the apparatus twice, measured nine bases aggregating 69 kilometers, or 43 miles, and incidentally traveled and transported our complete equipment more than 1600 miles by rail.

The iced bar (Fig. 1) used in standardizing the base apparatus was designed by Prof. R. S. Woodward, and first used by him on the Holton Base.* A steel bar five meters long, carrying a microscopic graduation on platinum plugs set in its neutral axis is sup-

* A full description of the apparatus may be found in Appendix No. 8, Coast and Geodetic Report for 1892.

ported in a Y-shaped iron trough in such a manner that it can be kept straight, both horizontally and vertically, while it is surrounded by melting ice and in contact with it. The length of this bar had been previously determined by direct comparison with the National Prototype Meter, and this again is known in terms of the International Meter.

When in use for measuring a line, three sections of portable track support the carriage. The observer at the rear end holds the bar graduation on the micrometer wire of a fixed microscope while the

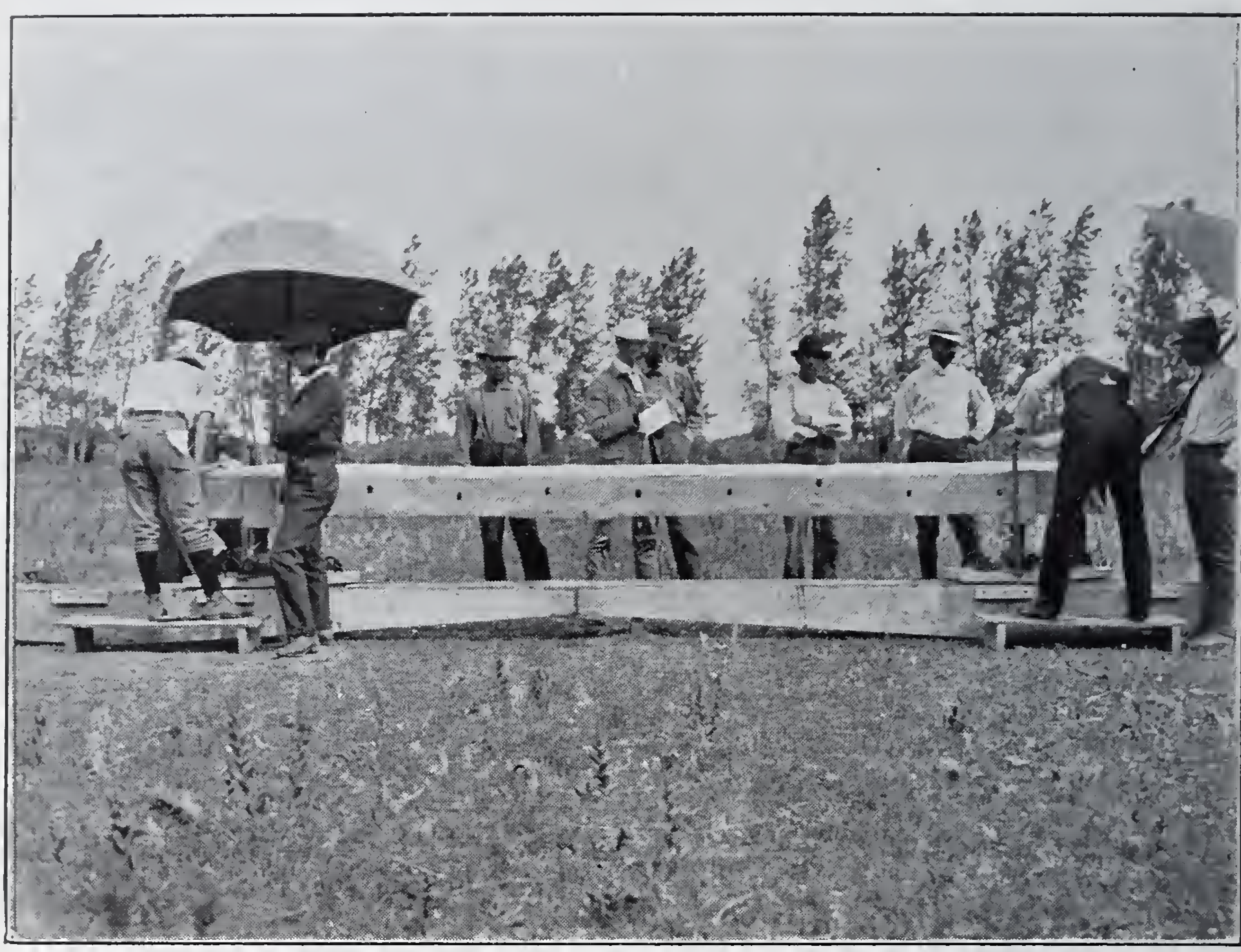

Fig. 1.—Iced Bar in Use.

observer at the forward end sets the microscope and reads the micrometer on the forward bar graduation. At each of the two field comparators stone monuments were set, at each end approximately 100 meters apart, carrying spherical-headed brass bolts. These bolts served to limit the distance accurately determined.

Beside the stone in position at the ends of the comparator, there were framed piers of four 6″ × 6″ pine, on which were microscopes to the optical lines of which the centers of the spherical-headed bolts were referred by using a piece of apparatus known as a cut-off cylinder

(Fig. 2). This cylinder carries a millimeter graduation, which can be raised and lowered to bring it into the focus of the microscope and an accurate level from which to read its inclination. The measuring then proceeded from one end to the other by steps of five meters. A row of 6″ × 6″ posts, set slightly to one side of the line at five-meter intervals, supports the microscopes, which are moved along with the progress of the measurement. The range of five double measures made on the Shelton comparator at the beginning of the season was 0.14 mm., or one part in 700,000, and the corre-

Fig. 2.—Cut-off in Use at Night.

sponding range of three measures on the Seguin comparator at the end of the season was 0.22 mm.

As soon as two measures of the comparator interval had been completed, the lengths of each of the five sets of apparatus, with which the bases were to be measured, were determined by measuring the 100-meter comparator with it, under conditions as nearly as possible like those encountered in the regular base measures, including the method of support and manipulation of the apparatus, and including, in the case of the tapes, even the use of the same spring balance to determine the tension. In this imitation of the base

conditions, each comparator was built in the open air with no protection from the sun and wind. The probable error of length of each piece of apparatus was easily brought below one part in a million, and no conclusive evidence was found that any apparatus had changed length during the season. The 50-meter and 100-meter steel tapes were about 6 mm. ($\frac{1}{4}$ inch) wide and $\frac{1}{2}$ mm. thick. With a spring balance a tension of 15 kilograms, or 33 pounds, was applied, and the tapes were supported at intervals of 25 meters. The temperature of the tape in each of its positions was determined by two mercurial

FIG. 3.—MAKING TAPE CONTACT AT END OF COMPARATOR.

thermometers tied with their metal backs against the tape, and about one meter from each end within easy reach of the observer. All the tape measures and comparisons were made at night (Fig. 3). The preparation for tape measures consisted of clearing out the line to a sufficient extent to allow of setting marking stakes in proper alignment and height at the points where the tape ends are to come, and tacking on the copper strips upon which the exact positions of the tape graduations are to be recorded, and finally the placing of intermediate support stakes in proper alignment and with supporting

nails in their sides at the proper height. This preparation of the line was done in the daytime. The number of persons necessary for measuring with the 50-meter tape was six, and with the 100-meter, eight.

There were forty-six sections, each, as a rule, about one kilometer long, of the nine bases, which were each measured forward with one tape, and backward with the other of same length. On 60 per cent. of these sections the difference between the two measures was not greater than 2.5 mm., one part in 400,000, and the greatest difference

Fig. 4.—Measuring with the Duplex Bar Apparatus.

was less than one part in 100,000. The maximum speed for any one night with the 50-meter tape was 1.3 miles per hour, and for the 100-meter tape, 1.7 miles per hour.

Each unit of the duplex apparatus (Fig. 4) consists of two 5-meter measuring bars of steel and brass respectively, mounted side by side within the same double tubular brass case. Three thermometers are so placed as to have their bulbs at the same height as the bars and midway between them. They are used as contact measures on tripods, or so-called trestles. The two bars within each case are so

mounted that the two measurements with steel and with brass proceed independently, the steel of the front unit being brought into contact with the steel at the rear unit at each measurement, and the brass with the brass. When the temperature is high, the brass, having the greater coefficient, gradually gets ahead of the steel, or falls back when the temperature is lower than that at which the brass and steel have the same length. This gain or loss is allowed to accumulate for a whole section, and is an accurate measure of the mean temperature of the bars, assuming that the mean temperature of the two bars is the same. The average speed on the last base, with the duplex bar apparatus, was nearly double that on the first base; the average for the whole season was fifty-three bars per hour, and the best record made was 100 bars (500 meters) in sixty consecutive minutes; previous to this the maximum speed was seventy bars per hour for only a short interval. This bar measurement takes two and three-quarter times as long as the tape measurement, and the accuracy secured with the two types of apparatus is about the same. As each base depended upon the five sets of apparatus,—the bars, two 50-meter tapes, and two 100-meter tapes, in about equal degrees,—it is believed that the remaining error in the final length of each base must be very small, presumably much smaller than on the typical base of the past, on which but one apparatus was used, and on which no conclusive evidence of the magnitude of the constant errors is available. The average probable error for the nine bases is one part in 1,200,000.

Precise Leveling.

The improvements in our precise leveling began in 1899, and were the direct result of action by Dr. H. S. Pritchett, then Superintendent of the Survey when a committee appointed by him made its report. The immediate result was to modify the instrument and drop the former method; but the full effect was not secured until 1900, when the Survey built a new level,* which has been unexpectedly successful. This instrument (Fig. 5), it is believed, although built for a precise level, if given a fair field of competition will drive the Wye level out of use. It was designed by Mr. E. G. Fischer, Chief of the Instrument Division. I am certain you will take more interest in this instrument

* For full description of this instrument, see Appendix No. 3, Coast and Geodetic Report of 1903, now in the hands of the printer and ready for distribution at an early date.

when I have told you what has been accomplished with it. It is stable and low, and can be used in very strong winds. The level vial is set down into the telescope tube, making the axis of the level as near the line of collimation as it is possible to have it, giving an advantage over any other precise or Y-level. The whole instrument is constructed of the nickel-iron alloy, with a coefficient of expansion about the same as pine wood. By means of an arrangement of mirrors the observer sees both ends of the bubble with one eye, and with the other reads the three lines of the diaphragm on the leveling rod

Fig. 5.—The 1900 Precise Level of the Coast and Geodetic Survey.

at the same time. It is like the dumpy level in having a fixed level vial and a telescope which cannot be turned on its axis. It has a quick-leveling screw, which allows a shorter time at the station, even with the 2″ level vial, than a Y-level with a 10″ level.

The rod is a "speaking" rod constructed of pine, well paraffined and graduated to centimeters. The method of observing is most simple, the observer reading the three lines of the diaphragm against the rod to the nearest millimeter. The stadia interval is about $\frac{1}{330}$.

Temporary bench marks are established at intervals of about one

Fig. 6.—A Leveling Party at Work.

Fig. 7.—The Observer Moving Ahead, Passing the Forward Rodman.

mile, and all sections are leveled forward and backward. The limit allowed between these two runnings is 4 mm. $\sqrt{K}$, where K is the distance in kilometers.

In our Survey we have one regular organization for a precise leveling party: an observer, a recorder, two rodmen, an umbrella man, and a general utility man (Fig. 6). As it takes but a few seconds to make the observations, much more time is spent in traveling than in observing. Where permits can be had, two velocipede cars successfully solve the transportation problem, and on one of these the observer rides between stations (Fig. 7). The recorder waits for the rear rodman to come up and he then takes him aboard and pulls ahead to the instrument station. As he passes the forward rodman, the mallet with which the foot-pins are driven down is handed to him (Fig. 8). Having reached the station (Fig. 9), the setting up is generally complete by the time the recorder is ready to record the observations on the (now) rear rodman (Fig. 10). The rodman (Fig. 11) has no target to set and read, and can watch the level on the rod, keeping it perfectly vertical during the observations.

FIG. 8.—RECORDER'S CAR PASSING FORWARD RODMAN.

Fig. 9.—The Observer in Position to Observe.

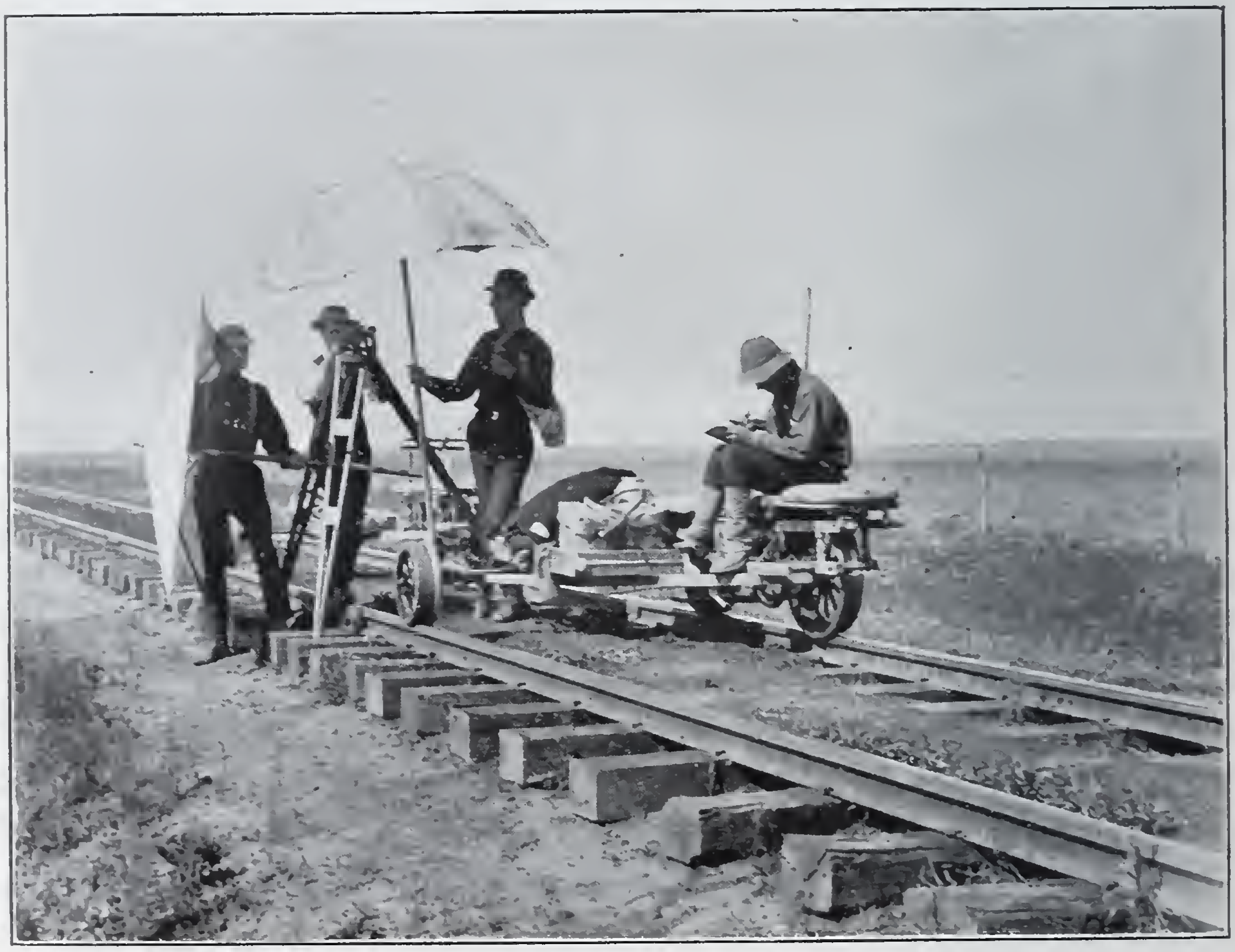

Fig. 10.—Making and Recording the Observations.

This party, in charge of Mr. W. H. Burger, between April 3 and November 18, 1902, ran 640 completed miles of leveling, an average of 85 miles each month; and in June ran 105 miles, which was 8.9 miles of single line for each observing day of only seven and a quarter hours. The sights averaged 83 meters (274 feet). Mr. W. C. Dibrell ran in one day 15.8 miles, none of which was afterward found to need

Fig. 11.—The Rodman.

re-running, averaging 1.6 miles per hour. This means that 2.9 minutes per station were spent in setting up and making the observations, calling the rate of moving between stations 6 miles per hour. And for four hours Mr. Dibrell ran at the rate of 2.1 miles per hour. This is what the Y-level must beat for speed.

The cost of our precise levels is $7 to $11 per mile of completed

line, while other leveling of as high a degree of accuracy as this has, in general, cost more than $16 per mile, and in some cases has cost double that amount. The real test of the accuracy, in addition to the limit of divergence (4.0 mm. $\sqrt{K}$) already mentioned, is the correction necessary when the lines are adjusted as a part of a net. In adjusting the loops already completed, the largest correction applied to any line of the new work is 0.00039 foot per mile.

The Triangulation.

The triangulation of last season is noted, not only for its rapidity, but also for its accuracy, and it is certainly among the most accurate arc measures yet made. This success would be of little interest if it were due to an unusual combination of circumstances, but again the plan of these operations included unusual features and radical departures. Foremost of the causes of success was the efficiency of the officers, not one of whom had previously made observations for primary triangulation. Mr. William Bowie, Assistant in the Survey, had charge of the work in the field. The expression "primary triangulation" brings to mind the camping two weeks to two months at a station, waiting for weather and to get very numerous measures. On this work, for each observer, the time at a station is four to six days, including the time spent in moving. This arc measured in these eight months covers six degrees of latitude, while the famous arc of Peru was but 3 degrees long, and the spheroid of Clarke in 1866, which this country has adopted, was computed from arcs aggregating but 90 degrees.

The unusual features are the wholesale one, the unusually large party; the reduction in the number of observations, and the party working under specifications. The instruments (Fig. 12) with which all the observations were made were constructed in the office of the Survey, and are remarkable mainly on account of the good design and excellent construction. The acetylene light on which more than one-half of the observations were made, is simply a bicycle light provided with a 5-inch lens. The rest of the observations were made on heliotropes. Two observers worked in conjunction along the two sides of the triangulation scheme, and employed the Morse alphabet to communicate with each of the light-keepers and with each other. This enabled the chief to direct the movements of every member of his party without the least delay, although they were in seven widely separated places. The direction method was

employed, and sixteen observations, and only sixteen, were made on each point, an observation consisting of a single pointing with the telescope direct and one with the telescope in the reversed position, the three micrometers being read on each. The positions were prescribed for the efficient elimination of the graduation errors of the instrument and the run of the microscopes. This number of

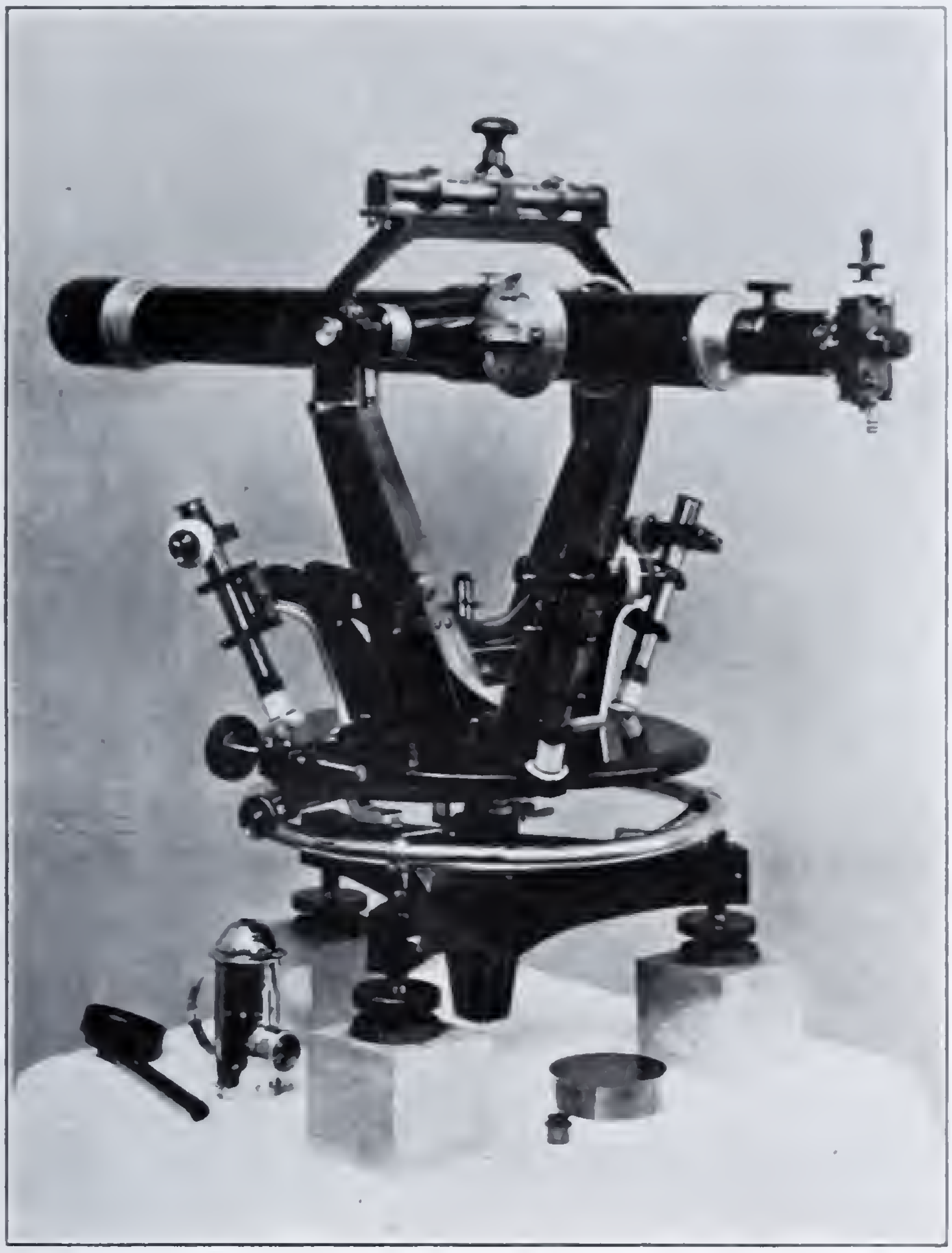

FIG. 12.—INSTRUMENT FOR MEASURING PRIMARY HORIZONTAL DIRECTIONS.

observations is about one-half the number customary over four years ago.

The progress of the observers at 55 miles, or five to seven stations per month, should be contrasted with that of one to three per month in previous work. The oft-repeated assertion that more accuracy is attainable over long lines than over short ones had to be abandoned

when as great accuracy was attained on these 10- to 35-mile lines as on the mountain lines of from 100 to 180 miles. The question has been often asked, as to how nearly the observed values of the directions hit the adjusted or true value which results from the adjustment by means of least squares to fulfil all the conditions of triangle closure and geometrical requirements. A station was selected

FIG. 13.—OBSERVING TOWER AT STATION CARSON; TABLE IS 80 FEET HIGH.

at random and the eighty observations made on this station from five different stations were plotted. This diagram showed that seventy-five out of the eighty actually strike on the table three feet square from which the lights and heliotropes were shown.

The usual measure of accuracy is the closure of the triangles. The average closure of the 136 triangles was 1.02″, while the specifications

called for 1.00″, and the maximum was 4.43″. The result of experience may be shown by the closure on the four different sections in the order in which the work was done: 1.36″, 1.05″, 0.97″, and 0.50″. The discrepancy between the computed and the measured length of the bases was between $\frac{1}{300000}$ and $\frac{1}{2000000}$, ranking with the best half of the triangulation the world over.

It was computed to be cheaper to build high signals than to do the necessary cutting, or to shorten the line. A signalman with six men preceded the observing party and erected 70 observing towers (Fig. 13), with an average height of 42 feet.

At present the indications are that the ninety-eighth meridian will be completed in about ten years, including all base measures and astronomical measures. To keep pace with the increased efficiency in every branch of engineering, I hope I have shown that in base-line measures, in precise leveling, and in triangulation the Coast and Geodetic Survey furnished no exception.

DISCUSSION.

The Chairman.*—We have been highly entertained and have obtained many new thoughts on the subject of geodetic work. I trust that the discussion on the subject will be full and complete.

Benjamin Franklin.—I would like to ask Mr. Baldwin if all the measurements were made at night; if so, between what hours.

Mr. Baldwin.—All the tape-line measures were made during the evening hours. All the bar measures, including the iced bar measures, were made during the day.

Mr. Franklin.—I presume that was for the purpose of eliminating the temperature error?

Mr. Baldwin.—Yes, sir; and we are looking forward now to the use of this nickel-steel alloy. The temperature can then be determined in the very roughest manner without the use of the thermometer. I believe that abroad they have succeeded in rolling out the metal into ribbon form, and the next time we have a number of bases prepared for measurement we hope to make use of that metal; in that case we would be able to measure in broad daylight. The only reason we did measure at night was because of the temperature.

The Chairman.—Mr. Silliman, will you favor us?

J. W. Silliman.—I would like to ask Mr. Baldwin what was the longest side of any triangle—the longest observation ever made or which is necessary to make in the working of the survey.

Mr. Baldwin.—I believe the longest line observed is one hundred and eighty-two miles; that was observed in both directions. I believe we have observations in one direction only, over lines nearly two hundred miles.

* Vice-President Silas G. Comfort in the chair.

The Chairman.—May I ask where the 180-mile line is situated?

Mr. Baldwin.—That is in the Rocky Mountains; one end is Mount Ellen, Colorado; the other is Uncompahgre Peak. Elevation is about fourteen thousand feet.

F. Schumann.—Are those base-lines ever referred back to the old Long Island base-line?

Mr. Baldwin.—Yes, sir. The Survey has a triangulation down the coast from Maine to Alabama and the old Long Island Base controls the length halfway between it and the Massachusetts Base on the north and half-way between it and the Kent Island Base over on Chesapeake Bay.

Mr. Schumann.—Never referred over to the west of the Mississippi?

Mr. Baldwin.—No; the effect of a base stops at the next base-line.

E. M. Nichols.—Do the base-lines start in with astronomical observations?

Mr. Baldwin.—No, sir. The astronomical measures are the last ones made. One astronomical position will allow us to compute the position of all the triangulation. The use of a triangulation in the determination of the earth comes in when there are a large number of astronomical observations. If we start on the Eastern coast and compute to San Francisco, then it is that we see how nearly the spheroid which we have adopted fits the true figure of the earth.

Mr. Nichols.—In making these triangulations, have you ever checked up to see how nearly correct was the original base of the western surveys and located at the mouth of the White River, Arkansas? Did you ever tie up to the old government surveys which control west of the Mississippi River—that is, in getting the number of the meridian?

Mr. Baldwin.—We have connected in that region a number of times, but I do not remember what that connection is.

Mr. Nichols.—Public land surveys of Missouri, Kansas, Illinois, Nebraska, Iowa, the Dakotas, Minnesota, and part of Wisconsin are made from the base at the mouth of the White River in Arkansas as the starting-point.

Mr. Baldwin.—I meant to say that between base-lines, where we start away from the base-line and compute through the triangulation, through the successive base-lines, the discrepancies which develop are the largest possible. That does not measure the uncertainty existing in lines which lie between those bases. If I start from the Page base-line and compute to the Salina base-line, I may expect to be out about one part in one hundred thousand. The lines of the triangulation between those bases would be much more accurate. The geodetic datum which we carry across the continent comes from a mean of all of the astronomical observations on the Atlantic coast. When these were carried across to San Francisco, they differed something like seven seconds in longitude from the observer over there. A portion of that is twist in the triangulation, while the rest is due to the deflection of the plumb-line at that point.

James Christie.—Probably the iron-nickel alloy referred to by Mr. Baldwin is that peculiar compound of French origin, termed by them "Invar." Is the production of this alloy so established that its coefficient of expansion can be definitely known?

Mr. Baldwin.—They are still experimenting on it. This metal of which the instrument is made has about the same coefficient as pine-wood. The temperature within five degrees would be accurate for measuring base-lines, where

they have almost zero coefficient by a proper mixing of the two. This alloy is altogether too soft to be rolled out into a tape. No one in this country, so far as I am informed, has used this metal in that way, but abroad they have used some such alloy in the measurement of base-lines.

The Chairman.—Professor DuBois, will you favor us with a word on the subject?

Howard W. DuBois.—I am particularly interested in the question of the practicability of the new alloy magnalium, which is composed of aluminium and magnesium, for the construction of geodetic instruments. As the Survey is making some of its own instruments, I should like to know if they have had any experience with this metal, as some foreign makers have claimed that lightness can be obtained without sacrifice of rigidity, which is usually the experience with all aluminium alloys.

Mr. Baldwin.—As far as I know, we have never used it in this country. What they have done abroad I am not able to say.

Now, I would like to ask you gentlemen something about the speed which a Y-level can make. I thought I would startle you with the record of our observers, of sixteen miles a day, and I would like to know how fast you would expect to level with a Y-level. Two and nine-tenths minutes per station—does not that seem small to set up the instrument and get through with the observations?

Mr. Nichols.—I have run twelve miles of levels in Dakota in one day with a Y-level, and walked it all afterward, checking back to within two-tenths, taking sights as long as one thousand feet sometimes.

The Chairman.—The hour is not late, and I am sure Mr. Baldwin will be pleased to answer any further questions in regard to the subject of his paper.

Mr. Silliman.—I would like Mr. Baldwin to explain what he called the base-net. He spoke of it in the early part of his paper.

Mr. Baldwin.—As the lines which we measure are only about four to eight miles in length, and the length of our lines as shown on the screen is about twenty miles on an average, it is necessary to multiply our base. The base-net is the best shape of triangles which we can arrange around this measured line to bring that length immediately up to the average length. You can readily see that the angle opposite the base has every time got to be a little smaller than sixty degrees. If it comes down to thirty degrees, the sine is changing rapidly, and the computed length becomes weak right away. By the strengthening of the base-net we mean making the best shaped triangles having angles as nearly equal to sixty degrees as it is possible to have them, in order to bring the measured line up to the average width of the triangulation.

Mr. Christie.—I am sure we all feel under obligations to Mr. Baldwin for the trouble he has taken in the presentation of this interesting subject to us this evening. I move that the thanks of the Club be offered to Mr. Baldwin for his instructive efforts. (The motion was carried unanimously.)

A CONSIDERATION OF THE GASEOUS FUEL PROBLEM.

HENRY G. MORRIS.

Read June 6, 1903.

Probably the earliest users of gaseous fuel were the fire worshippers on the shores of the Caspian Sea, where from time immemorial gas has been escaping from the oil belt of that region, only to be put to use on a large scale in modern times. But, to confine the subject of this paper to the artificial production of gas, the first efforts to evolve it from coal should be "credited to Murdock of Redwith, Cornwall, England, who, about 1789, amused himself and astonished his neighbors by riding about in a little steam carriage, which at night was lighted by means of bladders filled with coal-gas." *

In 1805 the use of coal-gas became general in the Manchester factories, England, and in 1807 was introduced in London, although characterized by Napoleon as "a grand folly," and Sir Walter Scott "feared London would be on fire by it from Hackney Gate to Tyburn." One critic said "the idea was worthy of the philosopher who proposed to extract sunbeams from cucumbers."

The first record we have of the use of gas in Philadelphia is in 1796, when Michael Ambroise & Company, "Italian fire workers," had an amphitheater for exhibitions, on Arch Street between Eighth and Ninth.† They displayed representations of temples, masonic emblems, etc., which they said were produced by "inflammable air with the assistance of light."

In 1803 I. C. Henfrey made a proposition to Councils to light the city by gas lights burned in high towers.

In 1816 Dr. Charles Kugler exhibited at Peale's Museum, in the State House, "gas lights, lamps burning without wick or oil." This lighting took place in April, and was so satisfactory that Warner & Wood, of the new theater, introduced the gas lights at the fall season of the same year.

William Henry, "coppersmith and tinsmith," constructed the ap-

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* E. E. Perkins, "Gas and Ventilation," 1856.

† Scharf and Westcott, "History of Philadelphia."

paratus for the use of the gas at the museum and theater, and was so well satisfied with the result of his work that he put up a gas apparatus in his own house, 200 Lombard Street, near Seventh, and invited Councils to witness the effect. This was the first private dwelling illuminated by gas in the United States.

The Councils' committee reported next year that they had examined the gas lights at the museum and theater, and while not taking any present action, recommended that a standing committee on gas should be appointed to learn something more upon the subject, and report from time to time.

"Peale continued to light his museum until the spring of 1818. His manufactory was in a small closet under the steps in the great hall leading to the upper floors of the State House building. Here he had a furnace and apparatus, and, the establishment being considered dangerous, objection was made to its further continuance, and he thereupon ceased that method of illumination."

The use of gas lights in Masonic Temple was brought to a close by the burning of that building in 1819. When the hall was rebuilt in 1822, new gas-works were erected and permission asked to extend pipes on streets to supply other consumers, but this privilege was refused by Councils, and predictions were freely made that gas as an illuminant would soon go out of use.

In 1825 an effort was made to induce the Legislature to incorporate the Philadelphia Gas Company, with authority to manufacture gas and lay pipes in the streets. Councils were aroused, and the proposition opposed. A writer in the "United States Gazette" denounced the project of lighting by gas to be "folly, unsafe, unsure, a trouble and a nuisance."

From this time until 1831 various efforts were made to enlist the interest of the public, and in 1832 a committee of Councils was appointed to investigate and report, which they did in the following year, with an estimate of the cost of gas for public lighting at $3.50 per thousand feet, exclusive of interest and salaries. In the city of New York, at that time, gas was sold to citizens at $7.00 per thousand.

Finally in extreme prudence Councils adopted the resolution that a person of scientific knowledge should be sent to Europe to examine into the methods of manufacturing gas there, and Samuel V. Merrick was intrusted with the duty, returning in December, 1834, with a very favorable report.

In March, 1835, Councils passed an ordinance appropriating $100,000

to construct works of 75,000 cubic feet daily capacity, on the site of the old Ninth Ward gas-works, which were finished and put into operation February 8, 1836.

Up to that time there had been only nineteen applications for private service. The price fixed was $3.50 per thousand, with a discount of 5 per cent. if paid within three days after presentation of bill.

From this small beginning has grown the present gas-works of Philadelphia, having a daily output of 15,000,000 cubic feet, with a constantly increasing demand, taxing the energies of those in control to keep pace with it.

The daily consumption of gas in Greater New York is said to now equal 90,000,000 cubic feet per day, which is at present produced in fourteen gas-works, but plans are in progress looking to the construction of a great producing plant at Long Island City, in which much of the work done in the smaller establishments will be concentrated, with economical results.

Whether this will be done by the use of by-product coke ovens, or by the ordinary process of distillation in closed retorts with supplemental water-gas apparatus, the writer is not informed, but it is evident that a continuous increase in consumption of gas is confidently expected.

More extended notice should be given to the subject of so-called water-gas, to which reference has been made, and credit given to the efforts of Faber Du Faur, C.E., who in the early 50's tried to produce carbonic oxid and hydrogen from the dissociation of water in the presence of incandescent anthracite coal. This experiment was made at the Trenton Iron Company's works, and was in only a measure a success, probably owing to the cooling down of the fuel by the vapor of water.

This difficulty was overcome by F. S. C. Lowe, by alternately blowing up the fuel with air to a vivid state of combustion, and then injecting the steam and enriching the gas produced with naphtha or crude oil.

A bitter struggle was for some years carried on between the producers of coal-gas from bituminous coal and the advocates of water-gas, until at length the fact was recognized that each method had its proper place geographically, or in a supplemental capacity, and with the result that the price of gas to consumers has been greatly reduced, and the volume consumed vastly increased, while capital has been still able to obtain a fair return.

It is a self-evident proposition that fuel in the ground is not available when an abnormal demand occurs, or when the average daily production is interfered with by strikes or other causes, and that, therefore, the tendency of effort should be to place stores of fuel where they can be conveniently called on in time of need, involving, of course, a continuous daily production under the most economical conditions.

The inadequacy of existing methods of fuel distribution was most marked in our great cities during the time of the coal strike and when the supplies at last began to come forward in limited quantity. The additional cost to the consumers will possibly never be properly estimated, but must have run into many millions of dollars, largely borne by those who could ill afford it.

A consideration of conditions which might exist with an adequate supply of fuel in the form of gas in place of the use of crude fuel for domestic purposes, with all the disadvantages of handling at comparatively great expense, the uneconomical use in ordinary stoves and heaters, the labor involved, and final cost of disposition of ashes, offers abundant food for thought.

Taking the city of Philadelphia as an example, we find that in the year 1869 the maximum consumption per day per capita was 6½ cubic feet, and the average consumption as stated by twenty-one gas companies was 5½ cubic feet per capita. The consumption in this city for the year 1902 was some 5400 million cubic feet, or about 12 cubic feet per capita per diem, showing that a considerable advance has been made in the use of gas for fuel, as is evidenced by the fact that some 40,000 gas stoves are reported to be in use.

It is perhaps a safe assumption that ten times as much fuel is required for heating and cooking as is required for lighting, so that there would appear to be a very large field of operations to be covered by the producer of gaseous fuel.

The development of the by-product coke ovens, which is being so rapidly made at the present time, would appear to offer the solution of the problem of furnishing gaseous fuel at a low rate of cost, and methods of distribution to comparatively long distances make it possible to locate the producing plants at convenient geographical and commercial points.

As an example, a plant is now in operation at Camden, N. J., turning out some 600 tons of coke per day, and probably over 2,500,000 cubic feet of gas—the coke finding a ready sale for cupola, and other

manufacturing as well as for domestic use, and the gas being distributed to various towns in the vicinity.

It would possibly be argued that there would be an excess of solid fuel produced in the form of coke, but this objection is answered by the possibility of converting this coke into water-gas, to be mixed with the gas produced from the previous distillation of the coal.

Reverting for a moment to the existing conditions in Philadelphia, where the daily output of gas is about 15,000,000 cubic feet, and supposing, for argument, that this amount might be increased six-fold by reason of general use for heating, it would mean a daily production of 90,000,000, and a very much better system of distribution than at present exists, possibly by districting the city into comparatively small units, and locating at convenient points in each district a gas holder, which would serve as a pressure regulator for the district, being kept supplied through mains and pumping plant from the storage holders of the works.

The rapidly increasing use of gas-engines of high powers, reaching even to 2000 H. P., is an evidence of the desirability from an economical standpoint of the use of gaseous fuel, opening up a wide field of problems which the engineer will be called upon to solve in the near future.

As an example, it is probable that fully 20,000 tons of coke is made per day in Beehive Ovens, within a short distance of the line of the Pennsylvania Railroad, between Altoona and Pittsburg, from which about 100,000,000 cubic feet of gas is discharged into the air or wasted, which, if converted into power through gas-engines, would represent 5,000,000 H. P. hours, or the effort of about 104 gas-engines of 2000 H. P. each.

Manufacturers of gas apparatus are now offering to guarantee the production of a H. P. hour for one pound of fuel—a result not at present attainable through the medium of steam-engines and boilers except by a most complex type of engine.

It is not the intention of this paper to go into any elaborate details of the methods which are being developed, notably by the United Coke and Gas Company, whose works at Camden, N. J., have been referred to—for that has been ably and exhaustively done in a paper read by F. Schniewind, Ph.D., before the Gas Section of the Engineering Congress at Glasgow, in which it is stated that 2241 coke ovens on the Otto system are in use or in course of construction in the United States, the largest installation being that of the Lackawanna Steel

Company, Buffalo, N. Y., comprising 564 ovens, the resulting coke being for use in blast furnaces, and the gas for fuel in the steel plant.

It is interesting to note that the blowing engines for these furnaces will be gas-engines, using the waste gases from the blast furnaces.

To quote from Dr. Schniewind's paper, referred to: "Since the autumn of 1898 the large carbonizing plant of the N. E. Gas and Coke Company has been in operation at Everett, near Boston, and the readiness with which the coke is disposed of for domestic and locomotive fuel is conclusive proof of the above statements. . . . . This plant of 400 Otto-Hoffmann ovens was erected by the United Coke and Gas Company. It produces 1400 long tons of coke per day, which is almost entirely used in Boston or vicinity."

The amount disposed of is as follows: To railroads for locomotive fuel, 700 tons; to steam plants, 350 tons; for domestic purposes, 350 tons.

Up to 6,500,000 cubic feet of illuminating gas are sold to various gas-works at Boston. It averages 19 candle-power without enriching.

Properly speaking, the plant at Everett is a coke and chemical works, producing ammonia, coal-tar, and derivatives; the gas being considered as a by-product.

In 1901 the total coke produced in the United States, according to "Mineral Resources," was 21,796,000 short tons, of which 5.4 per cent. was produced in by-product ovens; from which statement an idea of the possible development of gaseous fuel for domestic and manufacturing purposes can be obtained.

The paper of Mr. G. C. Atwater, read at the meeting of the A. I. M. E., in October, 1902, gives very interesting details of the development of the modern by-product coke oven, with illustrations showing the modifications rendered desirable in adaptation to existing conditions in this country.

DISCUSSION.

Max Livingston.—Mr. Chairman and Gentlemen: Thirty or forty years ago the opinion prevailed that a gas-holder could not be struck by lightning, and assuming iron oil tanks to be equally exempt from that danger, Pittsburg refiners did not hesitate to place such tanks immediately behind dwelling-houses. However, it soon developed that tanks for the storage of crude petroleum had under certain conditions a special attraction for lightning, with disastrous results. In regard to the striking of gasometers, I am told that about two years ago a small one was struck and damaged in Connecticut. This statement did not go unchallenged, and, furthermore, it was claimed that the gas-holder must have been defective. From personal observation at Point Breeze I know that

lightning will play on and around gasometers in quite a harmless manner, while, with oil tanks, it is only too often followed by terrible destruction.

Mr. Morris.—If the oil tanks had a closed top (I suppose they have) and the space above the oil were kept full of gas, would they not then be immune from being struck by lightning?

Mr. Livingston.—If it were possible to carry out that idea the tank would probably not be struck by lightning. But the frequently varying contents, subject to the influence of great temperature changes, would make it impracticable to keep a tank with a closed top supplied with a requisite amount of gas An excess would put an undue strain on the tank, while a deficiency, easily brought about by a cooling thunderstorm, might cause a collapse.

Mr. Morris.—That would be overcome by connecting up to a gas-holder which would keep the pressure uniform.

Mr. Livingston.—Similar experiments have been made and other devices have been tried, all of which proved impracticable.

Mr. Morris.—That is purely relative, as it depends on the price at which the Atlantic Refining Company sells its oil. The Diesel motor gives an economy of about 50 per cent. over an ordinary oil motor which uses about one pint of oil per horse-power hour, while half a pint would be about the amount a Diesel motor would give; but it is a very expensive machine. A machine that requires to be run under four hundred pounds pressure has to be built pretty thoroughly—a good deal more thoroughly than oil engines are built.

The President.—Gentlemen, Mr. Morris's paper is still open for discussion. We will be glad to hear from any member of the Club.

Edwd. S. Hutchinson.—I would like to ask Mr. Morris what coal is used in Boston.

Mr. Morris.—Nova Scotia—Dominion Company coal.

John E. Codman.—About four months ago I read a paper before The Engineers' Club in which I described the gas-engines then under construction by the Westinghouse Machine Company, of East Pittsburg, Pa., for the proposed high-pressure fire service of this city. These engines are to use illuminating gas manufactured by the process previously described in the paper just read, and the satisfactory results obtained from tests made with them for power and control of engines are an evidence of the rapidly growing use of fuels in a gaseous form for generating power through motors of this form. The engines were temporarily erected on foundations in the machine shop and connections made with the natural-gas supply obtained from driven gas wells on the company's property, and supplied to the engines through meters which measured and regulated the number of cubic feet supplied to each engine.

On May 12th and 28th, 1903, the engines were tested for development of power, cubic feet of gas consumed, excessive load, half load and no load, to comply with the terms of the specification and contract.

The engines are of the regular Westinghouse three vertical cylinder, four-cycle type, of 280 to 300 brake horse-power.

The resistance was obtained by means of a Prony brake applied to a large band wheel on the main driving shaft of each engine, the circumference of the lever arm being 32.8 feet.

The load on the brake arm, indicated by a platform scale, for excessive load

was 1750 pounds, the revolutions being reduced by this load to 139 per minute the idea being to show how great a resistance the engine could be made to work under.

The next trial was for overload. The load on the brake arm on the scale was 1500 pounds, and the speed 198 revolutions per minute; horse-power developed, 303. The engine was running very near the specified number of revolutions and developing over the horse-power required.

The next trial was for a full load. The weight on the brake arm was 1410 pounds; speed, 204 revolutions per minute; horse-power developed, 286. The engine ran perfectly free on the load it was intended to carry.

The next test was for half load. Weight on brake arm was 700 pounds; speed, 210 revolutions per minute, and horse-power developed, 246.

Next trial, no load. Weight on brake arm, 212; speed, 221 revolutions per minute; horse-power developed, 21.1. There has been considerable criticism in regard to the control of gas-engines, but these tests seem to show that engines can be controlled from the full overload of the engine to $21\frac{1}{10}$ H. P., which is practically no load at all.

The next test was to ascertain the effect in case of a break and release of the pressure. The load on the brake arm was arranged to be thrown off instantly. The engine was running at 200 revolutions per minute and developing 300 H. P. when the load on the brake arm was released. The revolutions increased slightly, but the governor reduced to normal in less than a minute.

The next trial was to show how soon the engines could be started and run at full speed. The starting power being compressed air admitted to one cylinder, the engine was stopped, and, after being placed in position for admitting the air, it was started again at full speed in twenty-five seconds. The amount of gas consumed when running full speed was twelve and a half cubic feet per hour per brake horse-power. Natural gas is computed to contain 960 heat units per cubic foot. Gas furnished by the U. G. I. Co. in this city is computed to contain 650 heat units per cubic foot. Engines using U. G. I. gas consume eighteen and four-tenths cubic feet per hour per brake horse-power; the number of heat units per hour being 12,000, equal to 200 heat units per brake horse-power per minute, or 165 foot-pounds per heat unit.

The specification for engines in the Bureau of Water requires 120 foot-pounds per heat unit, and the development on test of from 128 to 130 pounds per heat unit. This shows that the gas-engine as a heat engine is superior to the best steam-engine.

James Christie.—I infer, from the general tenor of Mr. Morris's remarks, that he directs an inquiry as to the probable character of the fuel that will be used in our large cities in the future. Will the fuel be in a gaseous or a solid form?

There is little doubt that in concentrated communities it would be very desirable to have gas distributed economically for domestic fuel. It is clean, comfortable, convenient, and in every way better than solid fuel.

The time is not far distant when the diminishing supply and the increasing price of anthracite coal will compel the greater use of bituminous coal. The large supply of bituminous coal and the reducing cost of placing it at the seaboard will create a spreading use of it; in fact, the use of bituminous coal has

been rapidly extending in our seaboard cities for several years, and it is quite likely that this extension will increase even more rapidly hereafter.

Such being the case, the smoke-prevention problem becomes a pressing question. It is well known that, under certain and favorable conditions, bituminous coal can be consumed without creating a smoky atmosphere. It is also in evidence that wherever bituminous coal is used extensively there is a smoky atmosphere, despite all the preventative ordinances or laws that have been enacted. There are two ways of disposing of this problem while continuing to use solid fuel. First, by coking bituminous coal and using the coke only as a solid combustible; the other is to compress the bituminous coal into suitable briquettes, when it can be burnt with the emission of little, if any, smoke.

To accomplish these purposes it would be necessary, in the one case, to have inclosed by-product ovens in the vicinity of the cities, where the gas evolved in the coking process could be stored and utilized and, if desirable, supplemented with water-gas made from the resultant coke; or else the coke itself could be distributed and used as fuel. In the other case briquetting plants could be established at the most economical points for compressing the bituminous coal and distributing the briquettes for domestic and other purposes in the cities. In this respect we can learn a lesson from German practice, where the briquetting of coal has been carried to a greater extent than elsewhere, and we are told that briquettes are now distributed in the principal German cities at prices that have a very attractive sound to us.

If the use of gaseous fuel is resorted to, probably the cost of its distribution would be the most serious element in the problem. Assume that the gas would carry 500 thermal units; one net ton of ordinary bituminous coal would be equivalent to 50,000 cubic feet of gas. With coal delivered at $5.00 per net ton, we could therefore afford to pay over 10 cents per 1000 cubic feet for gas. Considering its convenience to use and handle, we could probably afford to pay about 15 cents for the gas.

It is not at all improbable that coal briquettes could be delivered in our Eastern cities at a fair profit at the present prices of bituminous coal, at about the figure quoted above for the raw coal, for we are told that briquettes are now delivered in the German cities for about one-half this price.

In the natural-gas region, where this fuel is extensively used for domestic purposes, the price to large consumers varies, according to locality, from 10 to 25 cents per 1000 feet, averaging probably 15 cents. With natural gas carrying 900 B. T. U. and at a price of 15 cents, it is equivalent to ordinary bituminous coal at $4.30 per net ton. As this is a high price for bituminous coal in the vicinity of the mines, the coal still takes precedence of gas for steam-power purposes, and is still much the cheaper fuel, excepting cases where the gas is used direct in gas-engines.

If retort coke ovens are established near our Eastern cities, there will be ample demand for the gas produced, for use in gas-engines, and for power to supply power and electric light for the cities, and the coke will be in ample demand for industrial purposes.

Coke is not a desirable form of fuel for domestic purposes. Its light, open structure requires considerable space to store it, and large furnace chambers to burn it conveniently; furthermore, it does not bear handling without consider-

able loss by crushing. It would, therefore, appear to be desirable to resort to the use of briquetted coal, and it is probable that, in the not distant future, there will be an extensive use of fuel gas, conjointly with coke and briquetted coal.

We must avoid the use, so far as possible, of the coal in its natural state, or else submit to the smoke nuisance.

Mr. Morris.—There is no doubt that Mr. Christie's remarks are very appropriate. I think it is the Chinese who say water possesses that peculiar property of running downhill, and so it is with the method of heating. One man will use bituminous coal because he finds more heat units in a ton than in anthracite. Another don't care whether it smokes or not. Another uses anthracite because he has some regard for his neighbor's back yard. Those things will run along side by side with, I believe, the preponderance ultimately of gaseous fuel. I think it is to be hoped for, and I think it is attractive to the capitalist. He sees that the consumption of gas increases about 10 per cent. every year, and so long as they can do that, it is pretty good business.

Briquettes don't strike me favorably. I remember a good many years ago seeing them in use on the railroads in Europe. If you make them out of poor lignites and poor fuel, you are handling that much more ashes; and it costs something to put the coal in the form of briquettes. I doubt very much whether it can be done except under the extreme conditions of low wages. I don't think it can be done here to advantage. At $2.50 a ton it would seem as though the labor must be at a very low figure; and that idea is borne out by an account given by traveler Frank G. Carpenter some months ago, of his visit to Belgium, where they were making briquettes. Most of the labor was done by girls. I don't think we want to use them in this country.

A large concern in New York, manufacturers of gas-producing apparatus, are advertising and claim that they can furnish gas for a pound of coal per horsepower. In regard to briquettes, Mr. Jones can tell us something about briquettes—egg coal.

Mr. Jones.—Excuse me.

Mr. Morris.—I remember when he built the machines for making coal out of coal-dust for the Richmond wharves. It was a pretty expensive machine. Even with coal-dust, which is supposed to be a pretty good fuel at a purely nominal cost, it did not pay.

A Visitor.—There is the question of cost and the other question of convenience. There is, no doubt, a greater convenience in gas over coal. There is also another element entering into the matter, and that is the better character of the heat that is given by gas; just as when the electric light came out—it was a very nice thing, but going to be very expensive. A prominent railroad man said to me it is not a question of expense; we have a better light, and therefore we use it, and become accustomed to the better light. So with gas; we become accustomed to better and more convenient things. The question of cost lies especially in an industrial direction. When coal got up to $12.00 a ton, one individual thought he would put in a gas-pipe heater, and when he got his gas bill he was horrified. It would be interesting to know from Mr. Morris what he thinks the price of gas for domestic fuel should be if used in the city of Philadelphia to the extent of ninety as against twelve to fourteen now.

Mr. Morris.—I did not make the calculation. Tell me how much a ton of coal

is worth from the time it leaves the cars until the ultimate results are given out. Take everything that goes into the cost—handling from the cars, hauling, putting into the cellar, the waste from handling in the cellar, the damage to your curtains and furniture from the ashes and dust made. Compute all the items of cost from the time the coal reaches the coal yard until final disposition of ashes. Compare that with the cost of gas, and I think gas at fifty cents would be cheap.

A Visitor.—In Ohio I believe the agreement was reached that gas—ordinary illuminating gas—at about a dollar a thousand was equivalent to paying $20.00 for coal. It might be reduced all over the country and that would mean a very much cheaper gas. If gas sold at fifty cents, that would bring coal down to $10.00.

Mr. Morris.—I know several years ago I was informed that the cost of gas in a town of about two thousand inhabitants in the Western States—the cost of gas delivered to the consumer was forty-eight cents. That is, with very modern appliances. I think there is plenty of margin in making gas.

A Visitor.—I would like to ask if any gentleman can inform us what proportion of gas is furnished to the city free of cost. What is the proportion of the total amount used for which the gas company receives no pay? The reason I mention that is because I think that is why we have to pay a dollar a thousand in this city.

The President.—Mr. Morris, can you answer that question?

Mr. Morris.—I am afraid I cannot answer that question. The city receives ten cents royalty, I think, on every thousand. All they get is ninety cents. I think that is a correct statement of the case; but just how much is furnished free I am unable to say.

H. W. Spangler.—Any one interested in the cheap production of power will find an article in the "Engineering Magazine" for June, 1902, which gives a description of the sort of gas producer that, I think, Mr. Christie refers to. The title of the article referred to is "The Vevey-Mont Pélerin Funicular Electric Railway." A diagram of producer plant is given on page 369, "Engineering Magazine," June, 1902. The consumption of coal in this plant was from 0.60 to 0.65 kilogram of anthracite coal per horse-power hour, which is the equivalent of from 1.32 to 1.40 pounds of coal per hour. This efficiency can be obtained in this country, as the makers are now willing to guarantee a delivered horse-power of 1.5 pounds of anthracite per hour. Of course, these producers are made in very small units. I do not see how it is economical for one to put in a steam-engine and boiler, nor to use an ordinary gas-engine using city gas, if power is what is wanted. The cost of attendance is rather more than, I think, has been claimed by the makers. A 50-horse-power producer has a body of fire not much over 18 inches in diameter, and, as it would burn about 75 pounds of coal per hour, one can readily estimate the amount of attention the fire would require.

Mr. Morris.—What is the limit of pressure under which a gas producer can be operated? Taking a gun barrel as one extreme and an ordinary stove, for instance, as the other extreme, there must be some intermediate point at which solid fuel can be converted into the gaseous form with the greatest economy.

Mr. Christie.—I do not know under what upper limits of pressure gas producers can be economically worked. According to my experience, the higher

the pressure in the producer, the better the gas. Why, then, may be asked, not use higher pressure than is customary? Simply because, under high pressure, the clinkers are harder and more difficult to handle. Obviate this trouble and higher pressure will be used. The gas producer has been worked like a blast-furnace, using a fluxing material and discharging the non-combustible as a liquid slag.

THE BORDERLAND OF BIOLOGY AND ENGINEERING: EXEMPLIFICATIONS OF ENGINEERING PRINCIPLES IN LIVING STRUCTURES.

HENRY LEFFMANN.

Read September 19, 1903.

THE present communication is one of a class suitable only for occasional presentation to an organization such as this. The work of The Engineers' Club must in general relate to practical issues, and such has, indeed, been the characteristic of its proceedings throughout its existence. Nevertheless, it is wise for all scientific workers and investigators to step aside at times into the borderlands of other studies, and observe somewhat closely the relations of other sciences to their department of knowledge. In these days of highly developed specialism, it is necessary to the best culture and the best utilization of specialism itself to know something of outside science.

Believing that the members of the Club will be interested in a concise presentation of the exemplifications of engineering principles in living structures, I have arranged to exhibit this evening a collection of illustrations and specimens drawn from the wide field of biology and embodying a considerable variety of examples. Many of the data which will be presented are not unfamiliar, for the frequent occurrence in nature of structures that exemplify the adaptation of means to ends has been dwelt upon by many writers and has been specially brought forward in connection with some phases of theologic argument. The instances that I will bring forward to-night are but few out of the many that might be selected, for biology, as we know it to-day, presents a great variety of physical and chemical phenomena.

While the appropriateness and practical efficiency of many of the arrangements occurring in natural structures attract our admiration and even excite our wonder, we will find, on careful comparison with the highly specialized apparatus constructed by human beings, that the latter are more efficient, as a rule, for the purposes for which they are designed, and are constructed with more care as to the use of materials and the interdependence of parts. The eye, for example,

has long been admired as an optical instrument, but modern ophthalmology has shown that it is defective, in the majority of cases requiring marked correction for the proper performance of its functions. Even in its best condition it is inferior to the lenses now constructed for the microscope and telescope. As Darwin has pointed out, we may admire the ingenious arrangement of some of the orchids for securing cross-fertilization by insect agency, but on the other hand the means for securing fertilization in the cone-bearing trees are wasteful and clumsy. This inferiority of natural structures arises partly because of the limitations of vital action in the selection of materials of construction, and partly because the operations of nature are guided by certain inexorable laws, not by the intelligent direction of a free acting mind. Human beings utilize all the materials and forms of energy within their reach, but living protoplasm through which vital action operates is, with a few exceptions, composed of but few elements and capable of transmitting or transforming but few forms of energy. Many of the elements which are contained, or stored, in structures built by man are not only incapable of entering into living protoplasm, but are antagonistic to it.

Beginning with the simplest exemplifications, we have the instances of the bones of the skeleton, many of which illustrate the well-known principle of the hollow column, resulting in the greatest degree of strength with the least material. The articulation of the bones into the skeleton with movable parts involves the construction of joints and the application of power. The joints are provided with membranes which secrete a lubricating fluid, and, in the case of the human knee-joint, which sustains considerable weight and operates with great frequency and under conditions which involve much strain, an intermediate structure, tough and somewhat elastic, is interposed between the rolling surfaces. The general construction of this joint is complicated, and this accounts for the severity of the apparently trifling injuries to it. The joint construction of the elbow is interesting as exhibiting several forms of motion. The main bone of the forearm, called the ulna, moves upon the articulating socket of the arm bone, the humerus, by means of a hook-like depression, the point of the hook being received into the deep depression at the back of the humerus, so that the outstretched arm is rigid. We may notice an objectionable construction here in the fact that the nerve-trunk supplying a considerable portion of the hand passes directly over the back of the forearm bone beneath the skin, and thus this delicate

structure is easily injured by a blow upon the back of the elbow—the so-called experience of hitting the "crazy-bone." In the same joint is the rolling surface of the radius, in the form of a wheel-like expansion of the bone moving in the groove of the adjacent bone, and held in place by a band passing over the articulating surfaces and provided with a lubricating arrangement. By the rotation of

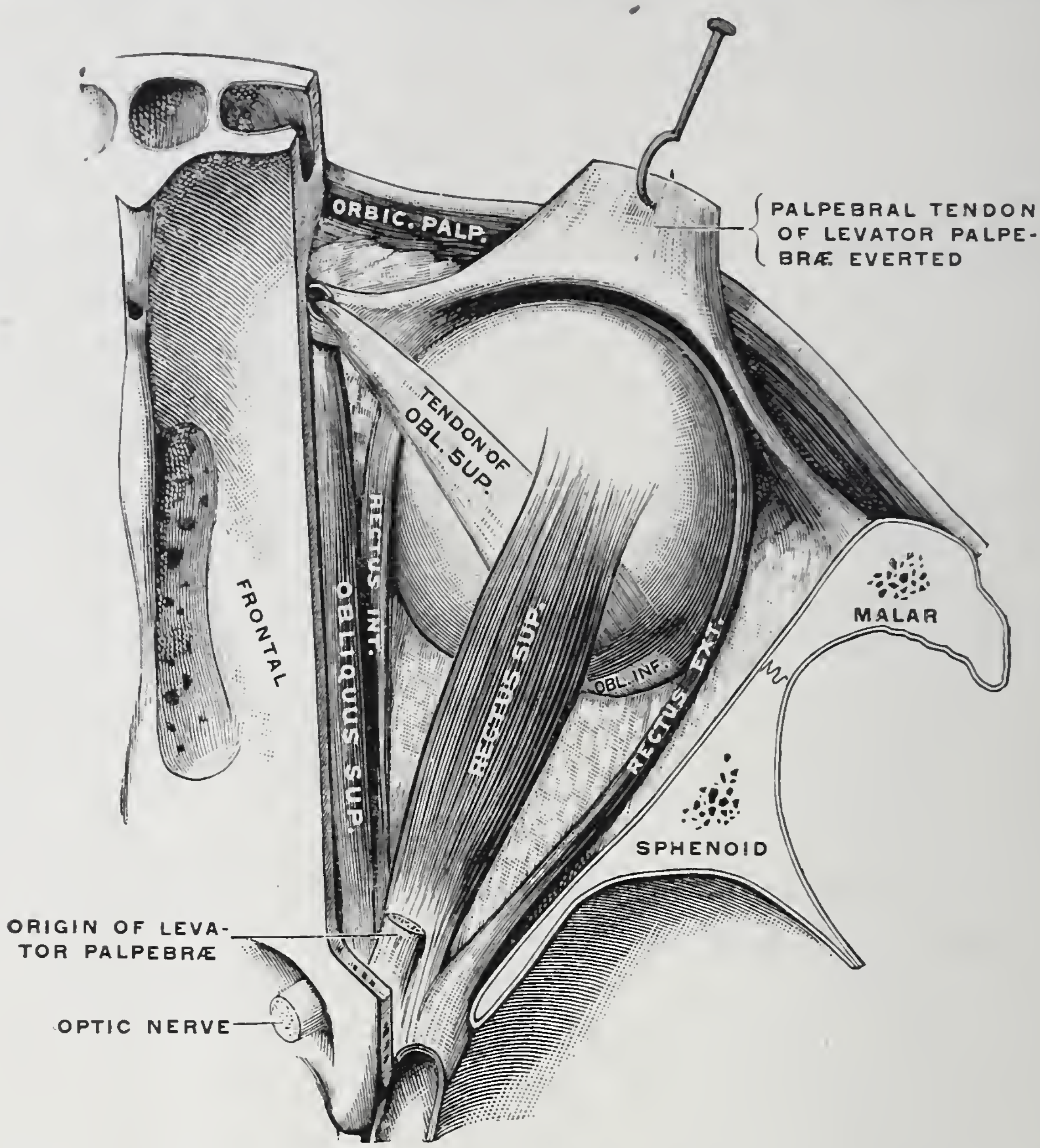

FIG. 1.—DISSECTION OF EYE MUSCLES, SHOWING TENDON OF SUPERIOR OBLIQUE MUSCLE PASSING THROUGH PULLEY.—(*From Gerrish's "Anatomy."*)

this bone upon its long axis the movements of pronation and supination are performed.

The operation of levers is abundantly exemplified. Many of the levers of the human body are of the third class, in which velocity is secured rather than power. In some cases a better application of the power is secured by means of an imperfect pulley attachment. Two striking examples of this modification may be specially noted: one is the omohyoid muscle passing from the hyoid bone at the top

of the larynx to the shoulder-blade. It passes through the loop of fibers lying beneath one of the larger muscles of the neck. In this way the motion of the muscle is obtained without so marked a projection from the line of the neck. Another example is the superior oblique muscle of the eye, which from its attachment at the back part of the orbit passes over the eyeball to the upper front part of the orbit through a loop which is attached to the bone at that point, and then, turning almost at right angles, is attached to the eyeball.

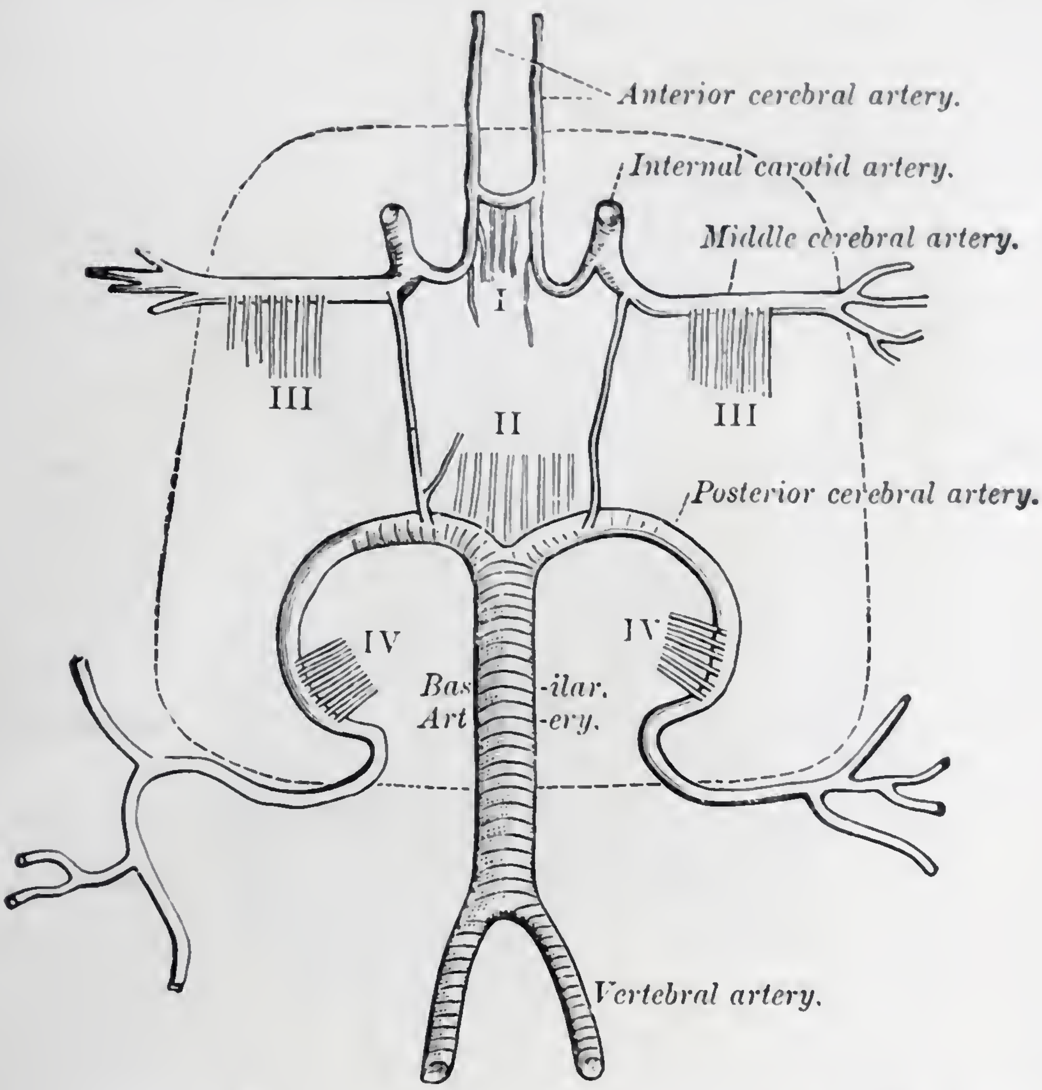

Fig. 2.—Circle of Willis as seen from Below.—(*From Gray's "Anatomy."*)

By the contraction of this muscle the eye is rolled in a direction which could not be so well attained by a direct-acting structure.

As many animals and some plants have circulating fluids, we find some applications familiar to hydraulic engineers; it is, however, only in the higher animals—man and his "near poor relations"—that we find the most striking examples of these principles. The circulatory system by which anatomists designate the entire series of vessels concerned in the movements of the blood, affords examples of pumps, valves, and pressure equalizers. The heart may be termed a pair

of double pumps. The venous blood is drawn into a chamber on the right side of the heart, called the right auricle, and passes into a second, larger, chamber called the right ventricle, from which it is pumped into the lungs. It returns into the left auricle, passes from there into the left ventricle, from this into the general circulation. The four chambers are made up of muscular tissue, and act by contraction. There is, therefore, no piston arrangement. To prevent regurgitation in the successive movements, valves are introduced at different points. These valves, when in good order,—which, unfortunately, is not always the case,—operate only in one direction.

The blood leaves the heart by a large trunk (the aorta), which is divided and subdivided after the fashion of gas or water mains, the bifurcations being usually, but not always, at acute angles. In the normal condition of the system there are no dead ends, but the fluid finds exit from every point which it enters, though often through an exceedingly fine network of tubes. The first branches given out by the trunk as it leaves the heart are small vessels connected practically at right angles and supply the heart itself. These, known as the coronary arteries, are protected from the strain of the full force of the blood-current by the fact that, as the valves placed at the opening of the aorta open, they press against the opening of the coronary artery and prevent the blood entering; when the valve closes, these arteries are filled by the recoil of the current.

In the supply of blood to the brain there is a very important problem to be dealt with. The human brain is larger in proportion to the size of the animal than any other brain and is also absolutely larger than any other existing brains except those of the elephant and the whale. It requires a great deal of blood and is supplied principally by four large trunks, two known as the carotids, passing up the anterior portions of the neck, and two, known as the vertebral, passing up along the spinal column. Just inside the skull and at the base of the brain these four vessels are connected by a series of cross-overs which will be better understood by reference to the accompanying illustration; the arrangement is known as the circle of Willis.

In the return of impure blood to the heart, through the veins, the sucking action of the heart is not very effective, and the movement is facilitated by the frequent occurrence of folds of membrane within the veins, which act as valves, permitting the flow of blood toward the heart or preventing its backward movement. These valves are

found principally in the arms and legs. They exemplify the condition arising from the evolution of the human being from four-footed ancestors. There are no valves, for example, in the veins of the intestines because the abdominal and pelvic cavities are so disposed in the four-footed animals that the blood flows easily from them toward the heart; but the upright posture of the human being involves a certain degree of mechanical insufficiency.

A simple but efficient and important valve is that which is placed at the junction of the small and large intestines. In the human

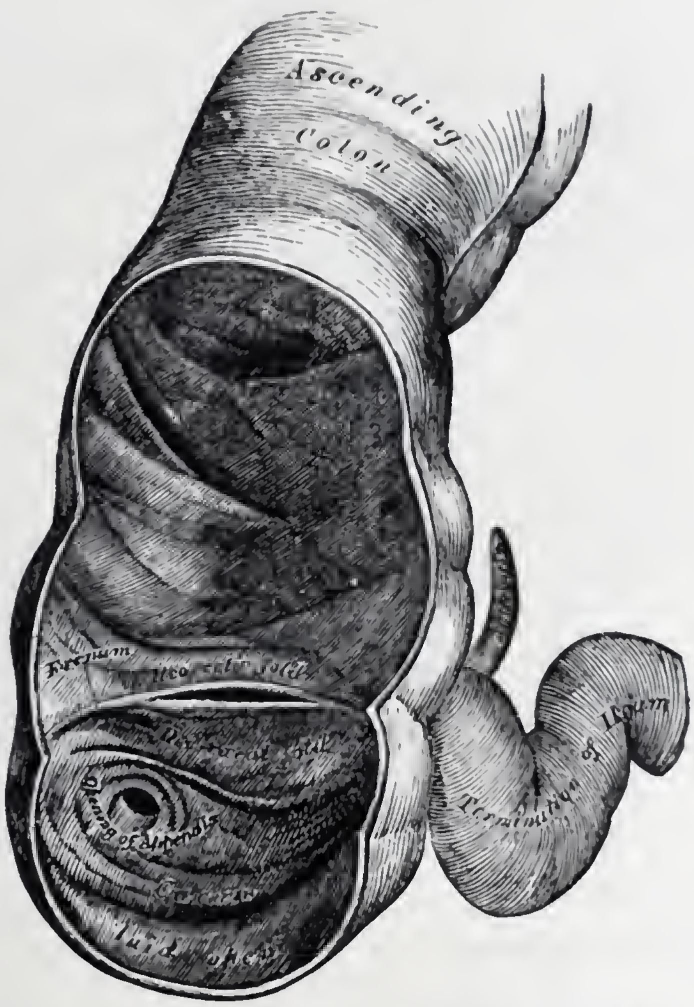

Fig. 3.—Ileo-cecal Valve.—(*From Gray's "Anatomy."*)

subject, the large intestine begins on the right side, ascends nearly vertically, crosses to the left, and descends. Near its origin in the lower right-hand side of the abdomen, it receives the termination of the small intestine, which enters nearly at a right angle. Well-marked folds of tissue at the upper and lower margins of the slit-like opening form a valve which allows materials to pass from the small intestine to the large, but obstructs the return movement. The cut shows the valve, and, incidentally, the opening of the appendix. This latter organ does not seem to have any useful function in the human being.

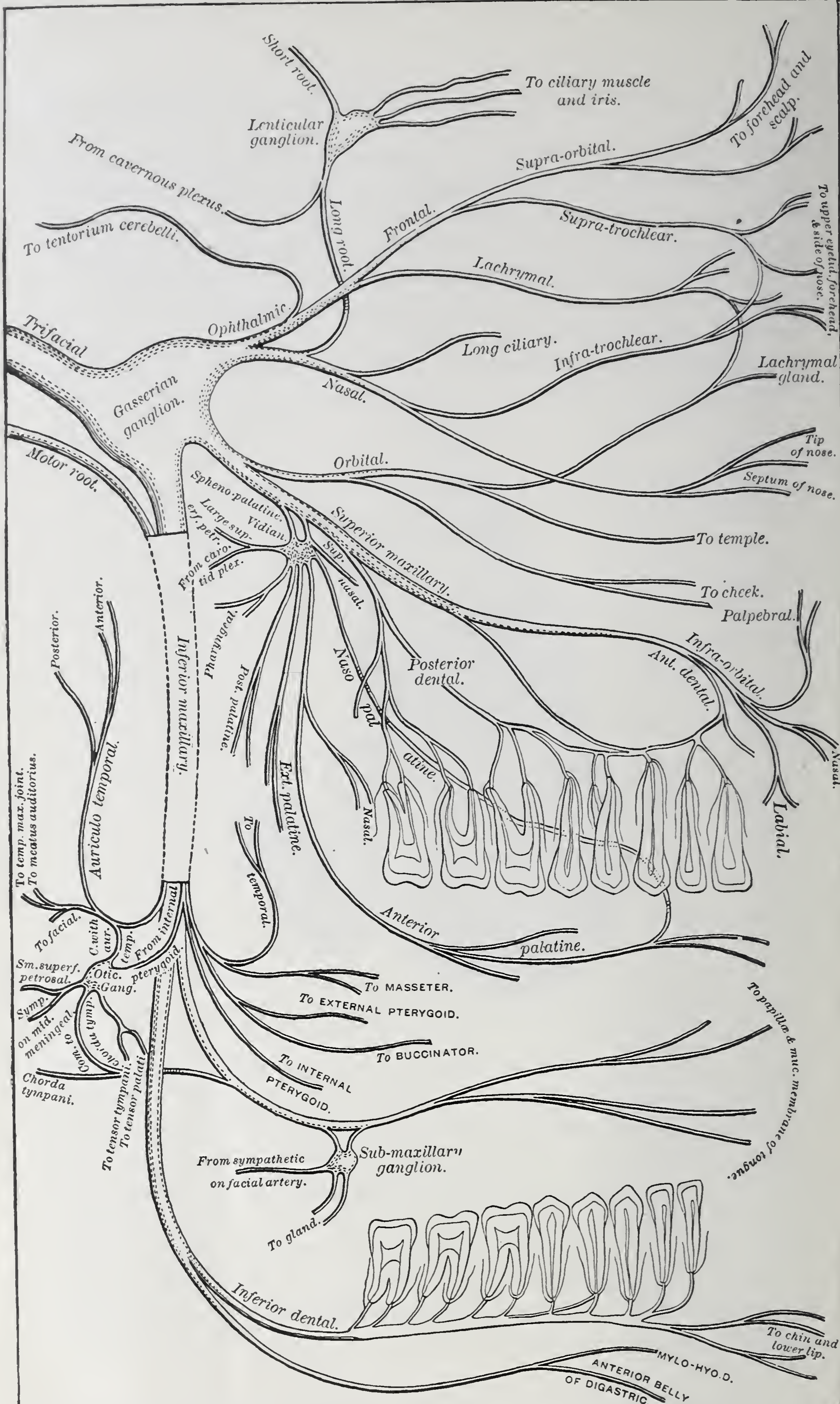

Fig. 4.—General Plan of the Distribution of Important Nerves of the Face.—(*From Gray's "Anatomy."*)

The distribution of the nervous centers and the reception of nervous impressions from nerve-terminals bear much analogy to the modern installations of electrical plants. Sufficient evidence is not at hand to justify us in regarding nerve-force as a form of electricity, but there are some striking analogies. The larger nerve-trunks, proceeding from the brain and spinal cord, divide and subdivide, until they become slender threads—and are finally lost in the organ of distribution. Two systems of nerve-supply are recognized in the higher animals: One, termed the "cerebro-spinal," originates in the brain and spinal cord, and is largely concerned with the higher functions, notably the special senses. The other system, called the "sympathetic," is centralized in a series of small masses distributed along the front of the spinal column. It is concerned principally with those functions that are not to a great extent under the will of the animal, such as digestion and respiration. The two systems mingle at many points. Each system exhibits secondary centers, called "ganglia," which may be points either for redistribution, for storing force, or for exaltation of force. They are thus suggestive of telephone poles, transformers, and boosters. The annexed cut of a part of the distribution of the nerves of the face will show some of the features.

A highly specialized form of nerve-force that is among the most wonderful of all these exemplifications, is the electrical apparatus of some animals. Electrical manifestations can be obtained from many forms of living tissue, but most of these are of the same order as those observed in non-living matter. The true electrical organs are forms of apparatus for producing distinct shocks, discharged through specially arranged electrodes. This subject is a difficult one. The materials for the study of it are not accessible, except to a limited extent; hence I can only give it a passing notice. It could only be treated in a special paper. Biologists are of opinion that the organs which develop electricity are modified muscle-tissue.

Turning to the vegetable world, we find that the exemplifications are less numerous and less brilliant, because of the more restricted functions of plants, especially as regards motion and higher functions. We find some simple mechanical principles, such as the hollow column, applied in the stems and larger branches. Plant-tissue also shows instances of reinforcement, somewhat analogous to reinforced concrete. We not infrequently see hollow structures, with light walls, with internal bracing or staying attachments. These points are exemplified in the annexed cuts.

An interesting instance of special adaptation is seen in some desert plants. These are subject to long-continued drought, and will suffer unless protected. On examining the skin of these plants, we find

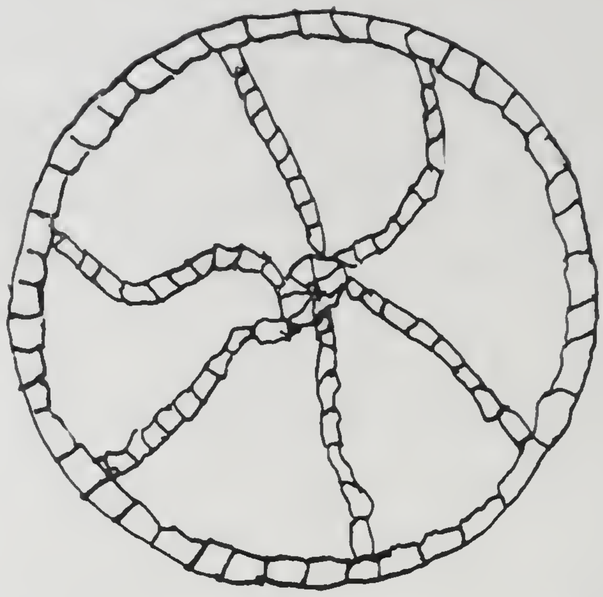

FIG. 5.—FLOTATION ORGAN OF UTRICULARIA STELLARIS, SHOWING INTERNAL BRACING.—(*Rough sketch from Goebel's "Pflanzenbiologie Schilderungen."*)

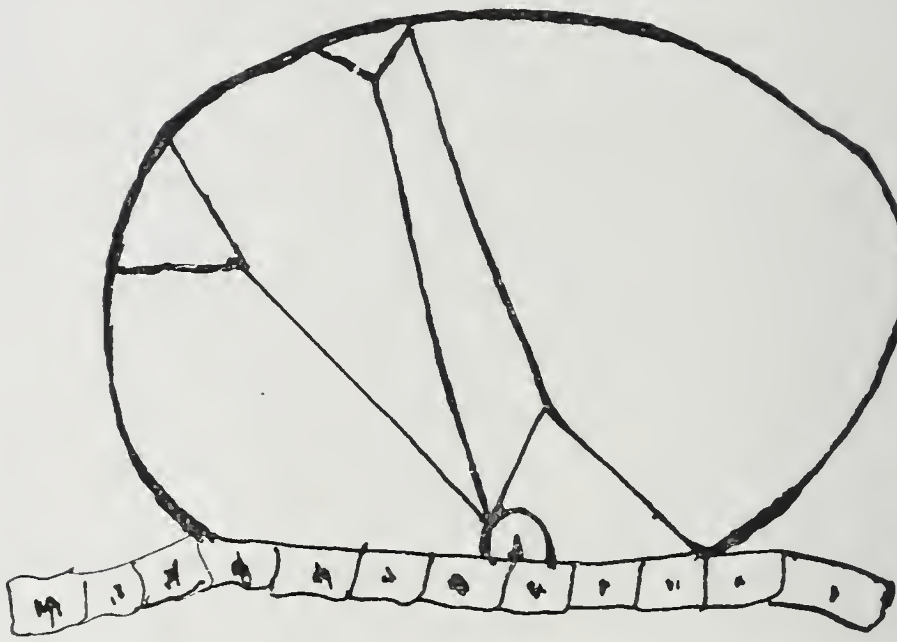

FIG. 6.—EPIDERMAL VESICLE OF MESEMBRYANTHEMUM CRYSTALLINUM.—(*Rough sketch from Haberlandt's "Pflanzenanatomie."*)

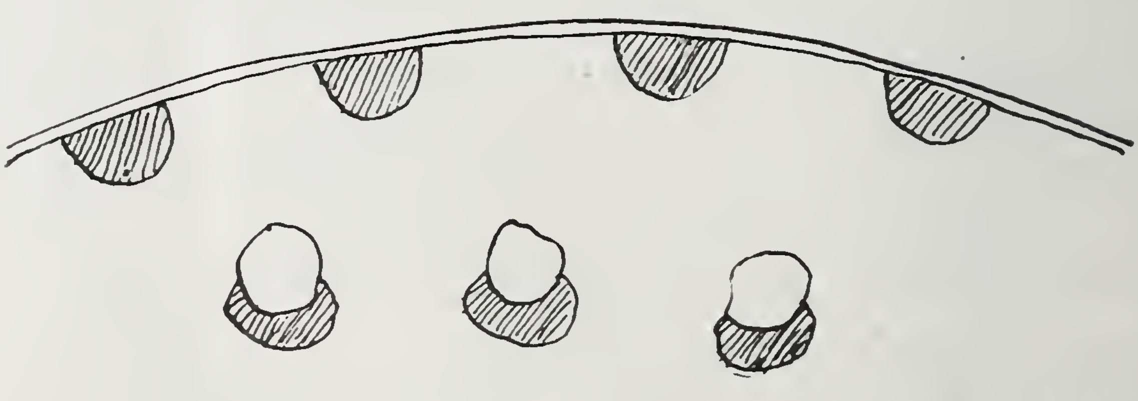

FIG. 7.—EPIDERMIS OF CYPERUS VEGETUS, SHOWING REINFORCEMENT OF TISSUE BY DENSER DEPOSITS.—(*From Haberlandt's "Pflanzenanatomie."*)

that the "stomata," or breathing pores, through which much evaporation can take place, are at the bottom of a deep depression, so that each pore is practically always shaded from direct sunshine.

A phase of mechanical adaptation in plants that has received great attention, and is believed to have exercised great influence on evolution, is the arrangements for securing cross-fertilization in plants. This is generally accomplished through the action of insects. Many curious mechanical devices are now known by which insects are attracted to flowers and compelled to take or leave pollen before they

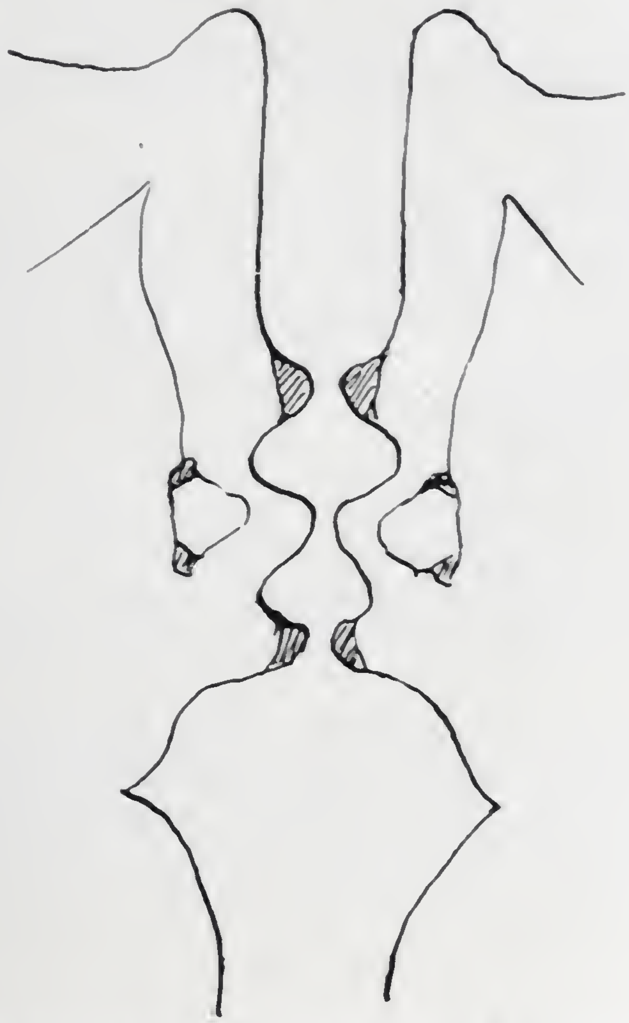

FIG. 8.—BREATHING PORE OF ALOE NIGRICANS, SHOWING LOCATION AT BOTTOM OF NARROW AND DEEP DEPRESSION TO RESTRAIN EVAPORATION.—(*From Strasburger's "Text-Book of Botany."*)

can escape from the flower. A discussion, even elementarily, of this topic would go beyond the limits of this paper.

I desire to acknowledge with thanks the assistance I have received from several sources: To the Biological Department of the University of Pennsylvania for loan of slides and suggestions of illustrations; to Dr. Harriet I. Noble, of the Woman's Medical College of Pennsylvania, for selection of specimens of human anatomy, and to Lea Brothers & Co., of Philadelphia, for permission to use cuts.

ABSTRACT OF MINUTES OF THE CLUB.

Business Meeting, September 19, 1903.—The President in the chair. Eighty-four members and visitors present.

Announcement was made that arrangements had been completed for an exchange of club house and library privileges with a number of engineering clubs and societies throughout the country.

A communication was presented from the Committee of the American Society of Civil Engineers on the Exposition at St. Louis, 1904, inviting the members of the Club to avail themselves of the conveniences to be provided by that society at their headquarters in the Liberal Arts Building.

The Nominating Committee as selected by the Board of Directors was accepted without change.

Dr. Henry Leffmann read a paper upon "The Borderland of Biology and Engineering: Exemplifications of Engineering Principles in Living Structures."

The Tellers reported the election of Messrs. J. H. M. Andrews, Henry D'Olier, Jr., Joseph W. Hunter, Chas. F. Mebus, Stephen L. Sinclair, and H. N. Twells to active membership.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS.

REGULAR MEETING, September 19, 1903.—Present: President Smith, Vice-Presidents Comfort and Foster, Directors Riegner, McBride, Bonner, Leiper, the Treasurer, and the Secretary.

The Treasurer's report showed:

Balance, May 31st,		$1991.35
June receipts,	$747.30	
July receipts,	231.10	
August receipts,	454.28	1432.68
		$3424.03
June disbursements,	$693.29	
July disbursements,	706.92	
August disbursements,	919.40	$2319.61
Balance, August 31st,		$1104.42

The Membership Committee reported two new applications on hand in addition to the eight just balloted for.

The Library Committee reported that the Reference Library was being indexed and that volumes in the general library were being arranged.

Mr. D. A. Hegarty's resignation from the Board was accepted with regret.

ADDITIONS TO GENERAL LIBRARY.

From Robert G. Dieck, Manila, P. I.

Report of the Municipal Board of the City of Manila, P. I., 1902.

From Wm. B. Phillips, Austin, Texas.

University of Texas Mineral Survey, Bulletin No. 6.

From University of Pennsylvania, Philadelphia.

Proceedings of Commencement, June, 1903.

From U. S. Civil-service Commission, Washington, D. C.

Nineteenth Annual Report.

From Harper Brothers, New York.

The Rise and Progress of the Standard Oil Company, 1903.

From James B. Bonner, Philadelphia.

Pocket Companion, Carnegie Steel Company.

From George S. Webster, Philadelphia.

Annual Report, Bureau of Surveys, Philadelphia, 1902.

From Harvey Linton, Altoona, Pa.

Annual Report, City of Altoona, Pa., 1903.

From the Pelton Water Wheel Company, New York.

Tangential Water Wheel Efficiencies, G. J. Henry, Jr., 1903.

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Business Meetings—When required by the Constitution or By-Laws, when ordered by the President or the Board of Directors, or on the written request of five Active Members of the Club.

The Board of Directors meets at 4 P.M. on the 3d Saturday of each month, except July and August.

ISSUED IN

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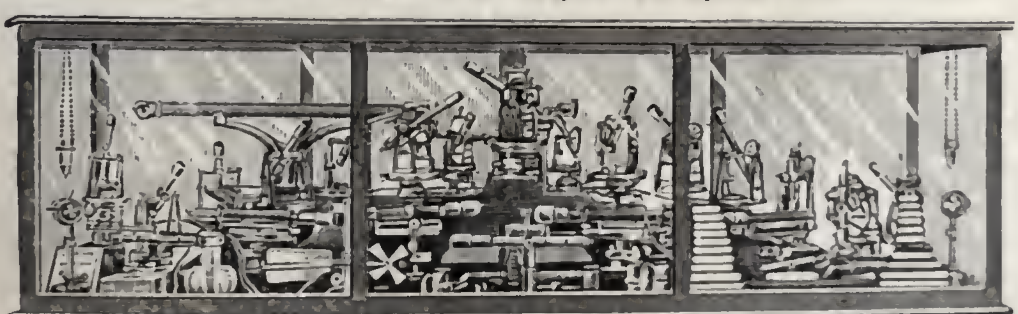

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